ERDC/CHL TR-16-1

Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

ERDC
INNOVATIVE SOLUTIONS for a safer, better world

Monitoring Completed Navigation Projects (MCNP) Program

Montgomery Point Lock and Dam, White River, Arkansas

Allen Hammack, Michael Winkler, and Howard Park

January 2016

ERDC/CHL TR-16-1
January 2016

Montgomery Point Lock and Dam, White River, Arkansas

Allen Hammack, Michael Winkler, and Howard Park

Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Corps of Engineers
441 G. Street, NW
Washington, DC 20314-1000

Under MCNP Work Unit: Montgomery Point Lock and Dam, White River, Arkansas

Abstract

Montgomery Point Lock and Dam employs a unique design and is located immediately downstream of a sharp curve in the White River, AR. Bathymetric survey data were collected during May 2008, September 2008, June 2009, and June 2010. A scour hole just downstream of the navigable pass deepened and widened between May 2008 and June 2009 to dimensions 23 ft deep by 115 ft wide by 260 ft long. It was recommended that the U.S. Army Engineer District, Little Rock, fill and stabilize the scour hole with stone large enough to prevent further enlargement with potential endangerment of the navigation structures. Approximately 4–6 ft of deposition occurred during this time period in very small areas of the upstream approaches to the lock. No maintenance channel dredging was required because these small sections could be easily obliterated by propeller wash. Current direction and velocity data indicate that much of the flow passes under and around the upstream floating guide wall due to significant outdraft and moves toward the navigable pass and overflow weir. This makes downstream barge alignment with the navigation pass difficult when there are moderate to high flows on the White River and the Mississippi River is falling. It was recommended that notices to mariners re-emphasize potential hazards under these conditions to avoid future allisions with the navigation structures. Loadings on the navigation crest gates were deduced to be well within safety tolerance by placing strain gages and accelerometers on the gate struts located in the galley of the dam to monitor strain loadings during raising and lowering of the gates. This study confirmed the findings of a previous physical model study that serious flow-induced vibrations do not occur during either raising or lowering the navigation crest gates.

Contents

Figures

Figures

Preface

The study reported herein was conducted as part of the Monitoring Completed Navigation Projects (MCNP) Program. Overall management of the MCNP is provided by Headquarters, U.S. Army Corps of Engineers (HQUSACE), Washington, DC. MCNP is one of the USACE Navigation Programs. The U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), Vicksburg, MS, is responsible for technical and data management and for technology transfer. HQUSACE MCNP Program Monitor at the time of this study was James E. Walker, Chief, Navigation Branch, HQUSACE. W. Jeff Lillycrop, CHL, was the ERDC Technical Director for Navigation. MCNP Program Manager was Dr. Lyndell Z. Hales, Technical Programs Office, CHL.

This research was conducted during the period October 2008 to September 2012 under the general supervision of Dr. William D. Martin, former Director, CHL; José E. Sánchez, present Director, CHL; Dr. Rose W. Kress, former Chief, Navigation Division (ND), CHL; Dr. Jackie S. Pettway, present Chief, ND, CHL; and Dennis W. Webb, former Chief, Navigation Branch (NB), ND, CHL; and Dr. Pettway, present Acting Chief, NB, ND, CHL. Principal Investigators during the conduct of this study were Michael F. Winkler, Howard E. Park, and Allen Hammack, NB, ND, CHL. Appreciation is extended to Cecil C. Dorrell, NB, ND, CHL, and Chris V. Lunderman, ERDC Information Technology Laboratory, who contributed significantly to the execution of this study. The assistance and guidance of U.S. Army Engineer District, Little Rock (SWL), MCNP Product Delivery Team members Glen Raible and Henry Himstedt, Lockmaster Christopher S. Turner, and Lock Operator Kathrene M. Harris are acknowledged with appreciation. This report was written by Howard E. Park. Acknowledgement and appreciation are also extended to Henry Himstedt and Joshua D. Krieger, SWL, for critically reviewing this manuscript and for providing many helpful suggestions.

At the time of publication of this report, COL Bryan S. Green was Commander of ERDC. Dr. Jeffery P. Holland was Director, ERDC.

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
cubic feet per second	0.0283	cubic meters per second
feet	0.3048	meters
feet-per second	0.0051	meters per second
kips	435.592	kilgograms
miles (U.S. statute)	1.6093	kilometers

1 Introduction

Monitoring Completed Navigation Projects (MCNP) Program

The goal of the Monitoring Completed Navigation Projects (MCNP) Program (formerly the Monitoring Completed Coastal Projects (MCCP) Program) is the advancement of coastal and hydraulic engineering technology with respect to U.S. Army Corps of Engineers (USACE) requirements. The program is designed to determine how well projects are accomplishing their purposes and how well they are resisting attacks by their physical environment. These determinations, combined with concepts and understanding already available, will lead to the creation of more accurate and economical engineering solutions to coastal and hydraulic problems. This will strengthen and improve design criteria, enhance construction practices and cost-effectiveness, and improve operation and maintenance (O&M) techniques. Additionally, the monitoring program will identify where current technology is inadequate and recommend additional research as required.

To develop direction for the program, USACE established an ad hoc committee of engineers and scientists. The committee formulated the objectives of the program, developed its operation philosophy and recommended funding levels, and established criteria and procedures for project selection. A significant result of their efforts was a prioritized listing of problem areas to be addressed. This is essentially a listing of the areas of interest of the program.

USACE offices are invited to nominate projects for inclusion in the monitoring program as funds become available. The MCNP program is governed by Engineer Regulation 1110-2-8151 (Headquarters, USACE [HQUSACE] 1997). A selection committee reviews and prioritizes the nominated projects based on criteria established in the regulation. The prioritized list is reviewed by the program monitors at HQUSACE. Final selection is based on this prioritized list, national priorities, and the availability of funding.

The overall monitoring program is under the management of the Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Research and Development Center (ERDC), with guidance from HQUSACE. An individual monitoring project is a cooperative effort between the submitting District or Division office and CHL. Development of monitoring plans and conduct of data collection and analyses are dependent upon the combined resources of CHL and the District.

Location and description of the project

Montgomery Point Lock and Dam (MPLD) is located within the U.S. Army Engineer District, Little Rock (SWL), on the lower White River in Arkansas, approximately 0.6 mile upstream from its confluence with the Mississippi River at River Mile 599 Above Head of Passes (RM 599 AHP). This first reach of the McClellan-Kerr Arkansas River Navigation System (MKARNS) follows the lower White River and is designated the White River Entrance Channel (Figure 1). The MKARNS extends from the Mississippi River upstream for 445 miles to the Port of Catoosa on the Verdigris River near Tulsa, OK. Construction on the MPLD project began in 1998, and the structure was placed in service 24 August 2004. A system of 18 locks and dams controls water depths for the entire MKARNS. The lower White River and its confluence with the Mississippi River are shown in Figure 2.

Figure 1. Location of MPLD, AR, on the White River at the confluence of the McKeller-Kerr Arkansas River Navigation System with the Mississippi River.

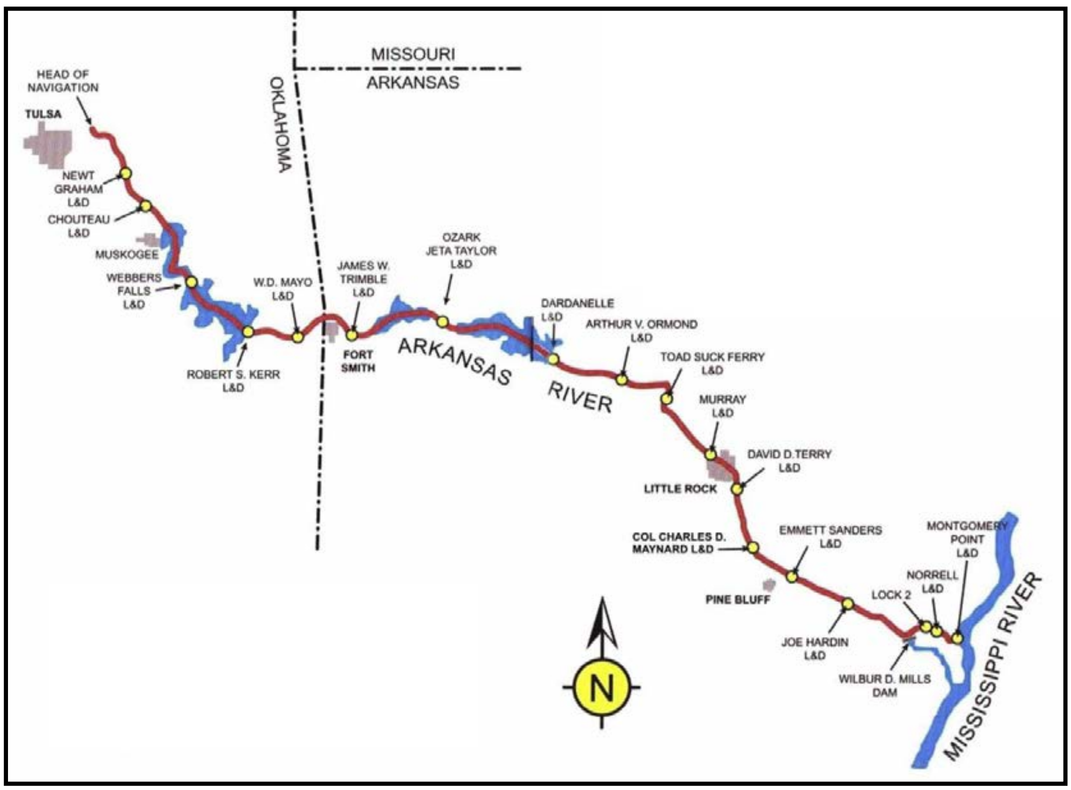
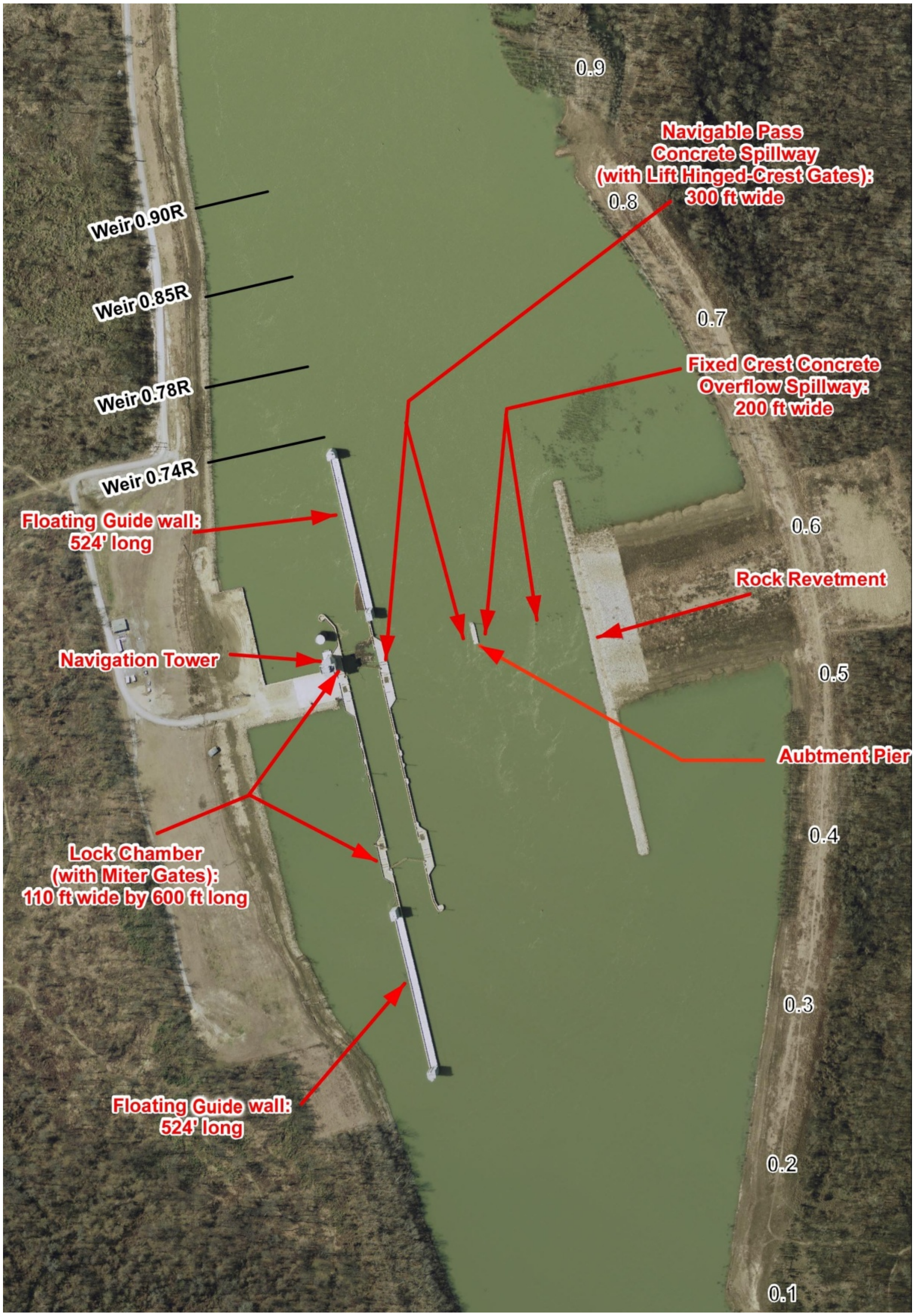


Figure 2. MPLD, AR, on White River at RM 0.6 from confluence with Mississippi River, at high water.

Montgomery Point Lock and Dam consist of the following principal features that are shown in Figure 3 by USACE St. Louis District, Applied River Engineering Center (AREC) (Cox et al. 2011):

- single-chamber lock on the right descending bank (RDB) with usable dimensions 110 ft wide by 600 ft long, lock floor elevation 77.5 National Geodetic Vertical Datum of 1929 (NGVD29)
- floating upstream guide wall approximately 524 ft long
- floating downstream guide wall approximately 524 ft long
- unique, 300 ft wide, bottom-hinged, torque-tube crest gate navigable pass (crest elevation 102 ft [NGVD29], with ten 30 ft wide gates) located between the lock and a concrete abutment pier
- a 200 ft wide, fixed-crest concrete overflow spillway located between the concrete abutment pier and a spur dike attached to the left descending bank, crest elevation 115.0 ft (NGVD29)
- four submerged dikes (weirs) with minimal height and effect on flow (approximately 5 ft high), located along the RDB at RMs 0.74, 0.78, 0.85, and 0.90.

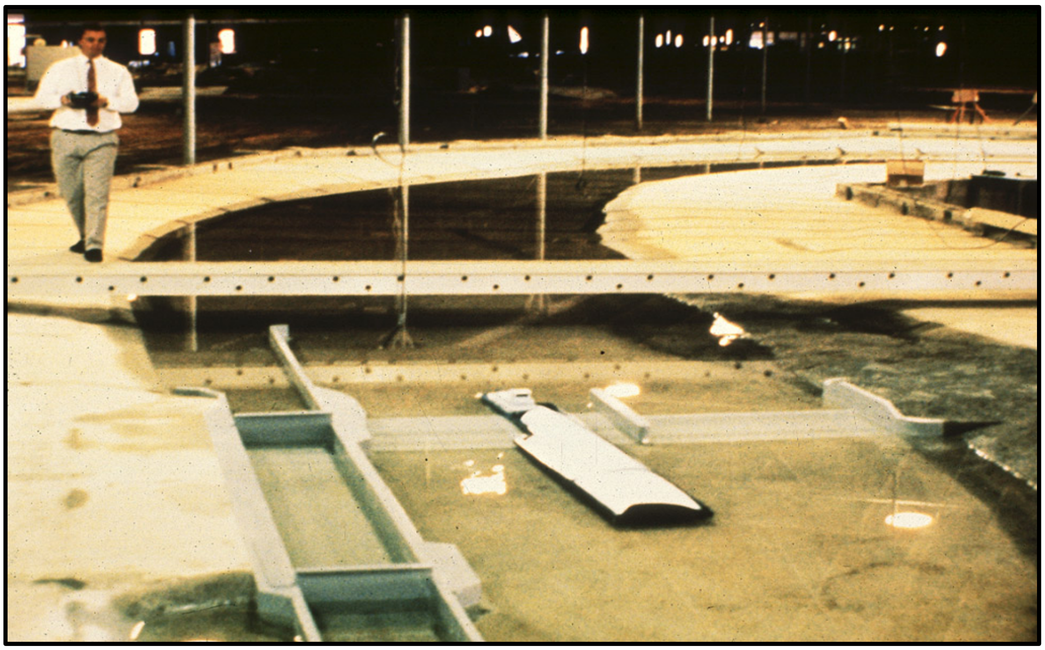
Figure 3. Features of MPLD at high water, by USACE AREC (Plate 2 of Cox et al. 2011; by permission).



Development of Montgomery Point Lock and Dam (MPLD)

MPLD and existing river training structures were designed from alternatives evaluated at the ERDC, Vicksburg, MS (Wilson 2007a), using a 1:100 scale three-dimensional fixed-bed hydraulic model (Figure 4). A physical hydraulic model was considered the appropriate tool to design the project for navigation and subsequently was used to address channel development while cofferdams were in place during construction.

Figure 4. Fixed-bed hydraulic model at ERDC of MPLD.



A three-dimensional moveable-bed sediment model (1:80 vertical, 1:20 horizontal) was also constructed at ERDC (Wilson 2007b) to evaluate how the structure would pass sediment through this reach of the river. This model investigated deposition upstream of the navigation pass. The use of submerged weirs in the bendway upstream of the lock improved the channel in the bendway and maintained the channel into the lock approach but could not maintain the approach to the navigation pass. Therefore, the bendway weirs were deleted from the project design. However, four submerged dikes were installed in the upstream lock approach (Figure 3) to improve navigational conditions into the mooring area (Carter 2005). These submerged dikes were added to better allow access to the mooring area for the river fleet during high flow conditions.

Evolution of shorelines, revetments, and spur dike in the vicinity of MPLD are shown in Figures 5 through 13, as extracted from Google Earth.

Figure 5. White River, AR, prior to construction of MPLD, 2 March 1996 (photo from Google Earth).

Figure 6. MPLD under construction, 24 January 2001 (photo from Google Earth).

Figure 7. MPLD at low water, 10 November 2005, after being placed into service 24 August 2004 (photo from Google Earth).

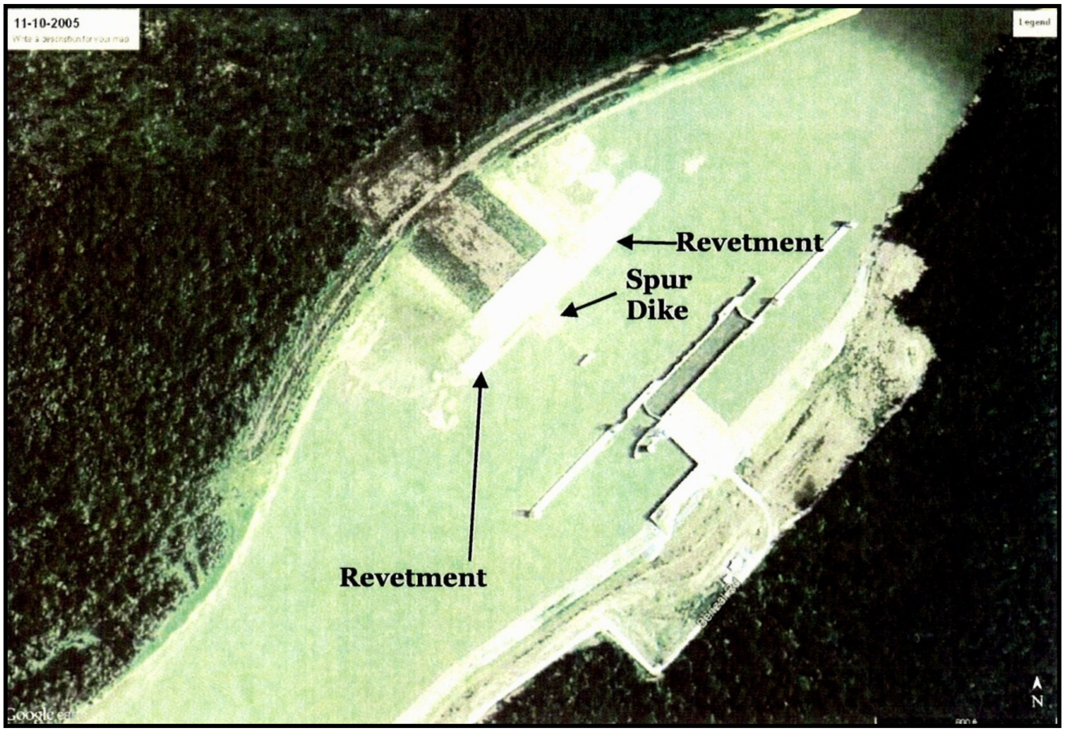


Figure 8. MPLD at higher water, 3 March 2006. Note spur dike and most of revetments are under water (photo from Google Earth).

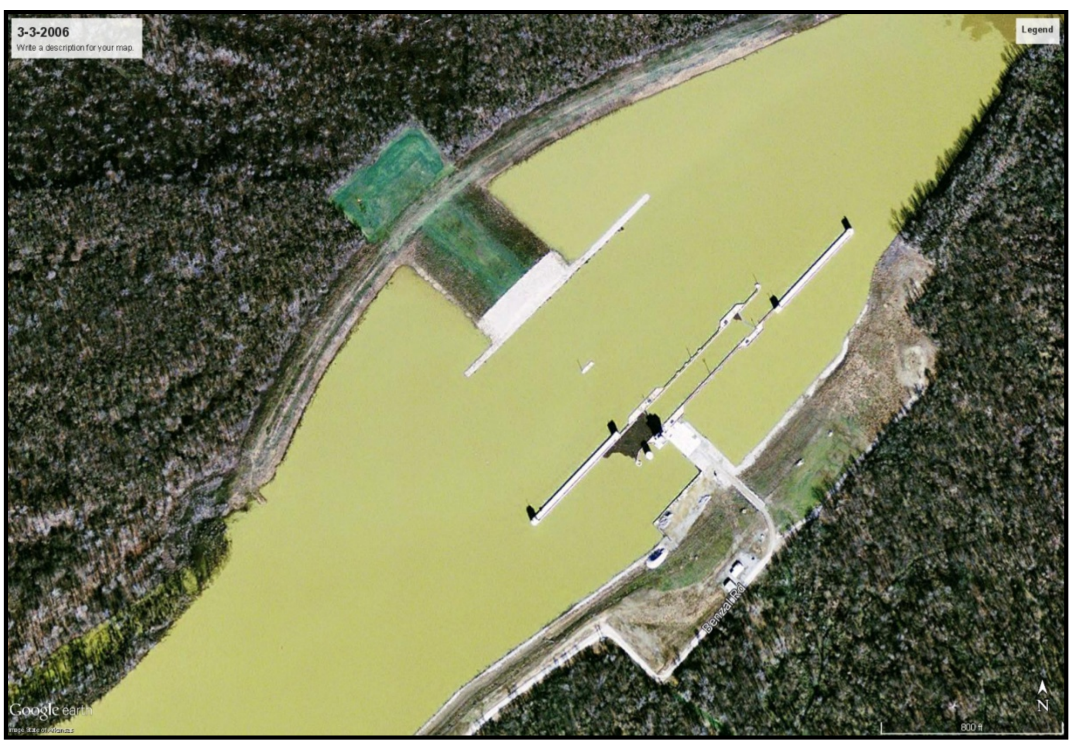


Figure 9. MPLD at low water, 19 September 2007, 3 years after construction. Note sediment accumulation upstream and downstream of earthen dam behind revetments (photo from Google Earth).

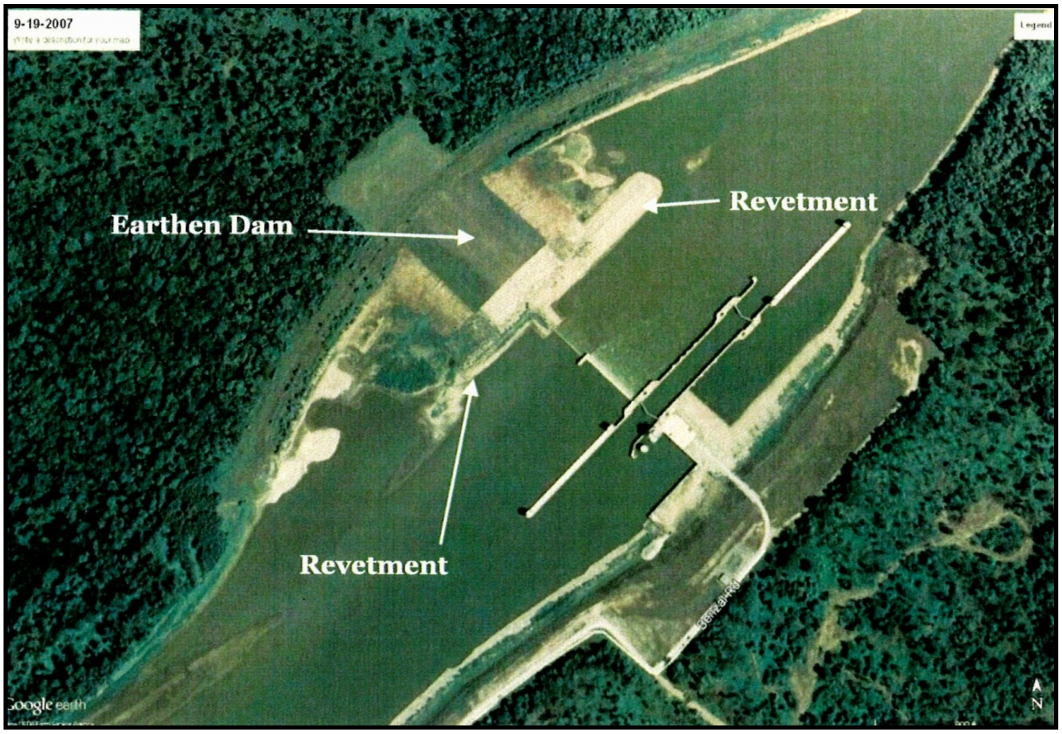


Figure 10. MPLD at higher water, 13 October 2010. Most of sediment accumulation upstream and downstream of earthen dam behind revetments is underwater (photo from Google Earth).

Figure 11. MPLD, 6 January 2013. Note continuing sediment accumulation upstream of earthen dam, infringing on navigation channel (photo from Google Earth).

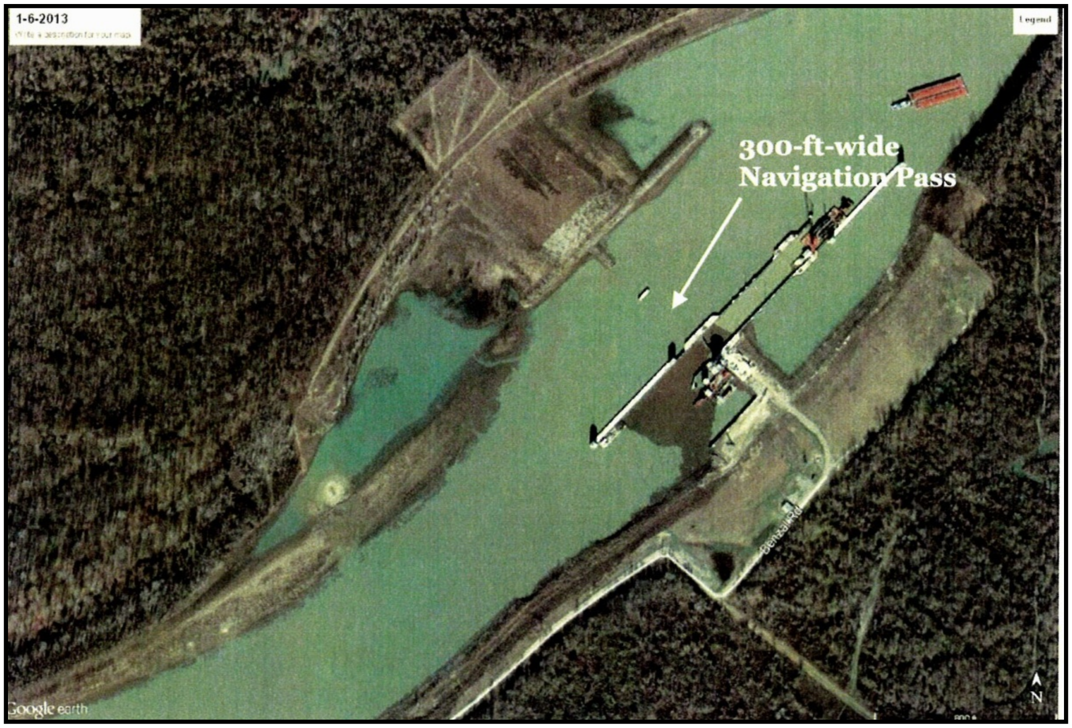


Figure 12. MPLD spur dike, revetments, and 200 ft wide overflow spillway, and 300 ft wide navigation pass, 6 January 2013 (photo from Google Earth).

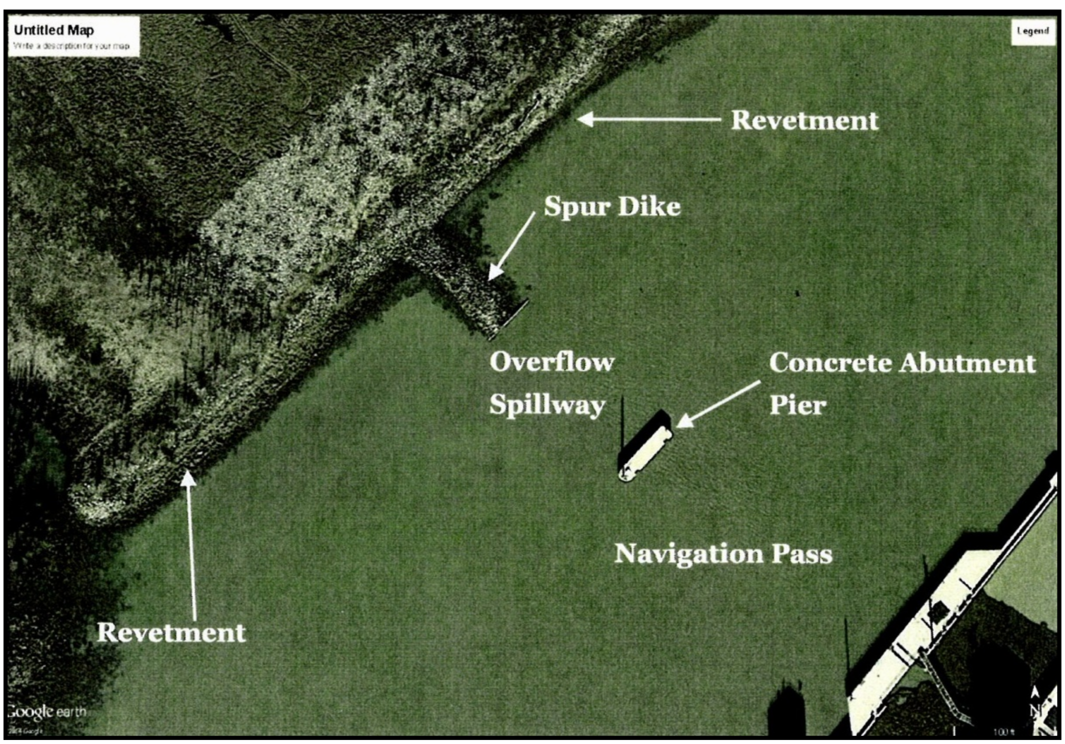


Figure 13. Close view of spur dike, 6 January 2013 (photo from Google Earth).

2 Monitoring Plan

MPLD was placed into service 24 August 2004, and included the first-of-a-kind hinged gates that could be lowered to lie horizontally on the crest of the navigation pass (the bottom of the river) during high water conditions on the Mississippi River, and barge traffic would travel over the lowered gates (through the open-water navigable pass) (Figure 3). During low water conditions on the Mississippi River, the hinged crest gates would be raised by hydraulic cylinders operating from a concrete tunnel underneath the White River to maintain appropriate pool elevation upstream of MPLD, and barge traffic would pass through the lock.

Because of the unique hinged crest gates and uncertainties regarding their operational performance, by memorandum of 17 February 2005 from the U.S. Army Engineer District, SWL, MPLD was nominated for inclusion in the MCNP program. Funds became available to initiate monitoring of MPLD in October 2007. The nomination letter from SWL emphasized the importance of MPLD and the absolute necessity for satisfactory performance due to its vital importance to the towing industry as it is located at the entrance to the MKARNS from the Mississippi River. MPLD provides a stable navigation pool for the first 10 miles of MKARNS.

Seven elements of the MPLD project were proposed to be monitored by SWL: (1) scour hole downstream of the overflow spillway and the navigation pass, (2) sedimentation and deposition upstream of navigation pass, (3) lock and navigation pass upstream approach velocity conditions, (4) spillway gate leakage, (5) forces on crest gates, (6) impact loads on floating guide walls, and (7) seismic monitoring of control tower monolith. After selection of MPLD for monitoring by the MCNP Program, a Product Delivery Team meeting was held at SWL on 24 July 2007. At that meeting, it was decided that proposed monitoring elements No. 6 (impact loads on floating guide walls) and No. 7 (seismic monitoring of control tower monolith) would not be pursued in this study.

All field data acquired during the monitoring period would be transmitted to SWL for District decisions regarding any navigation operational modifications or O&M issues pertaining to scour below and sedimentation above the navigation pass. These field data of single-beam, echo-sounder bathymetry and ADCP velocity data might, in turn, be forwarded to the

U.S. Army Engineer District, St. Louis (MVS), AREC, for additional analyses and interpretation.

Scour hole downstream of overflow spillway and navigation pass

The grade of the stone protection downstream of the overflow spillway and navigation pass would be monitored to ensure grade and section are maintained. The degree and rate of scour hole dimension change would be documented to verify estimated O&M costs and to make appropriate stone placement for maintaining a stable channel below the overflow spillway and navigation pass.

Sedimentation and deposition upstream of navigation pass

Deposition between the navigation pass and revetment 2.6 L upstream would be monitored to validate estimates used to forecast (O&M) dredging costs. The ERDC movable-bed model study indicated that bendway weirs upstream of MPLD were ineffective in maintaining the approach to the navigation pass. Therefore, these bendway weirs were deleted from the project design. Bathymetric survey data would be collected by ERDC and SWL at four different times with a 200 Khz, single-beam, echo-sounder hydrographic survey instrument to obtain bathymetry and compare channel development during the study period.

Three surveys would be conducted by ERDC in May 2008, September 2008, and June 2009. The intent was to collect these data during high- and low-water periods; however, dates of actual surveys were close but not precisely at high and low water elevations due to field data collection staff scheduling conflicts. Subsequently, another survey was conducted by SWL in June 2010. Bathymetric data from all four of these surveys were transmitted by SWL to USACE AREC for analyses and interpretation.

Lock and navigation pass upstream approach velocity conditions

Four submerged dikes (weirs) were installed in the upstream lock approach to improve navigational conditions into the mooring area and to allow better access to the mooring area for the SWL river fleet during high flow conditions. Potential problems of navigational alignment of barge traffic would be identified and could possibly be minimized by monitoring this project. Time-lapse photography to monitor tow approaches to the lock to validate the ERDC navigational physical model would be obtained.

The navigation physical model identified conditions where lockage would be difficult. The collection of data from actual lockage would identify if design criteria were appropriately gleaned from the model.

Discharges and velocities

The ERDC 1:100-scale, fixed-bed navigation model showed that navigation conditions were satisfactory for (a) an 8-barge, down-bound tow entering and exiting the lock, (b) an 8-barge, up-bound tow entering and exiting the lock, and (c) up-bound and down-bound tows passing through the navigation pass. Less than satisfactory conditions were observed in the mooring area for 15-barge tows. For the mooring area, revetment 2.0 R was realigned, and submerged dikes (weirs) were installed in the upstream lock approach to improve navigation conditions. Current direction and velocity data near the mooring area would be collected by MCNP. Current direction and velocities in the vicinity of the overflow spillway's left abutment along dike 0.6 L and the right abutment of the navigation pass were of particular interest.

Acoustic Doppler Current Profiler (ADCP) current direction and velocity data would be obtained during the same three time periods that the ERDC echo-sounder channel bathymetry surveys would be obtained (May 2008, September 2008, and June 2009). Subsequently, current direction and velocity data were obtained by SWL in June 2010. Current direction and velocity data from all four of these surveys were transmitted by SWL to USACE AREC for analysis and interpretation.

Tow time-lapse videos and automatic identification system (AIS)

The design normal barge impact loads on the upstream and downstream guide walls are up to 365 kips, with extreme impacts up to 535 kips. Barge impact design forces are only crudely estimated from mathematical models. It is expected these impacts will occur to the guide walls with some regularity, especially the upstream wall due to the extreme navigation approach angle for tows heading downstream. When combined with video camera data, the barge impact loads could be correlated with barge speed and angle of approach.

Time-lapse video equipment would be installed at the project to observe navigation conditions for tows entering and leaving the lock and transiting the navigable pass. Automatic identification system (AIS) instrumentation would also be installed at the lock to observe vessel traffic through the general vicinity of the lock, including traffic on the Mississippi River.

Spillway gate leakage

Leakage under and between the gates had been directly measured in the rigid gate model at ERDC. The maximum leakage rate measured in that model was 1.720 cfs. With two slightly widened gate gaps, the leakage used for design was 1,800 cfs. The leakage should be measured to validate model estimates.

Spillway gate leakage would be measured when the gates are raised. The gates are raised when the tailwater of MPLD recedes to elevation 115 ft NGVD29. Leakage determination at the prototype MPLD cannot be directly measured. An estimation of the leakage under and between the gates would be inferred by taking ADCP velocity measurements in the water column below the raised gates and integrating over the cross-sectional area to determine the approximate water quantity passing the raised gates.

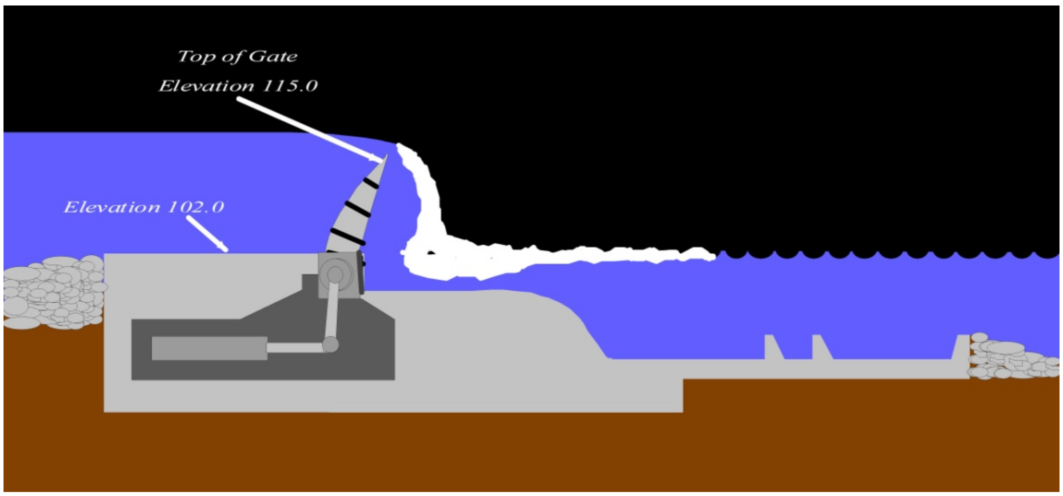
Forces on crest gates

The total load on the hinged, torque-tube, crest-gate hydraulic cylinders would be monitored. Expected normal loads are 200 kips tension to 500 kips compression. Overloads can be up to 760 kips maximum compression. These gates have a unique design with forces derived from hydraulic model studies. Such measurements would help confirm how the model loads scale to the actual structure. Strain gages and accelerometers would be installed on the hydraulic cylinder rams located in the galley of the dam to ascertain the forces and moments of the bottom hinged crest gate during operation and while the gates are in the raised position.

3 Operation of MPLD

MPLD was put into service 24 August 2004. As the Mississippi River elevation recedes below elevation 115 ft NGVD29, the gates in the navigation pass portion of the dam are raised to ensure a minimum 9 ft pool behind the dam for navigable depths upstream of MPLD (Figure 14).

Figure 14. Schematic of hinged, torque-tube crest gate in raised position to create navigation pool upstream of MPLD.



ERDC and SWL conducted 200 Khz single-beam, echo-sounder bathymetric and Acoustic Doppler Current Profiler (ADCP) velocity data surveys at four different times. Three of the surveys were conducted by ERDC: (1) May 2008, (2) September 2008, and (3) June 2009. The fourth survey was subsequently conducted by SWL in June 2010. The three ERDC surveys extended upriver to approximately RM 2.0 while the SWL survey extended upriver to approximately RM 4.0. Data from the three ERDC surveys were delivered to SWL and were subsequently transmitted by SWL to the USACE AREC, St. Louis, MO, for additional analyses. Data from the subsequent SWL survey in June 2010 also were transmitted by SWL to AREC for additional analyses. Using data from these three ERDC and one SWL field surveys, AREC (Cox et al. 2011) conducted an analysis of existing flow mechanics, and concluded the following:

> As a result of the new lock and dam, the previous navigation channel was shifted from the RDB north towards the center of the river between RMs 0.0 and 0.9 [Figure 15]. This relocation of the navigation channel created significant outdraft when there are moderate to high flows on the White River and the Mississippi River is falling (Cox et al. 2011).

Figure 15. General flow trends indicated by ERDC and SWL ADCP field velocity surveys, as interpreted by USACE AREC. (Graphic 1 of Cox et al. 2011; by permission).

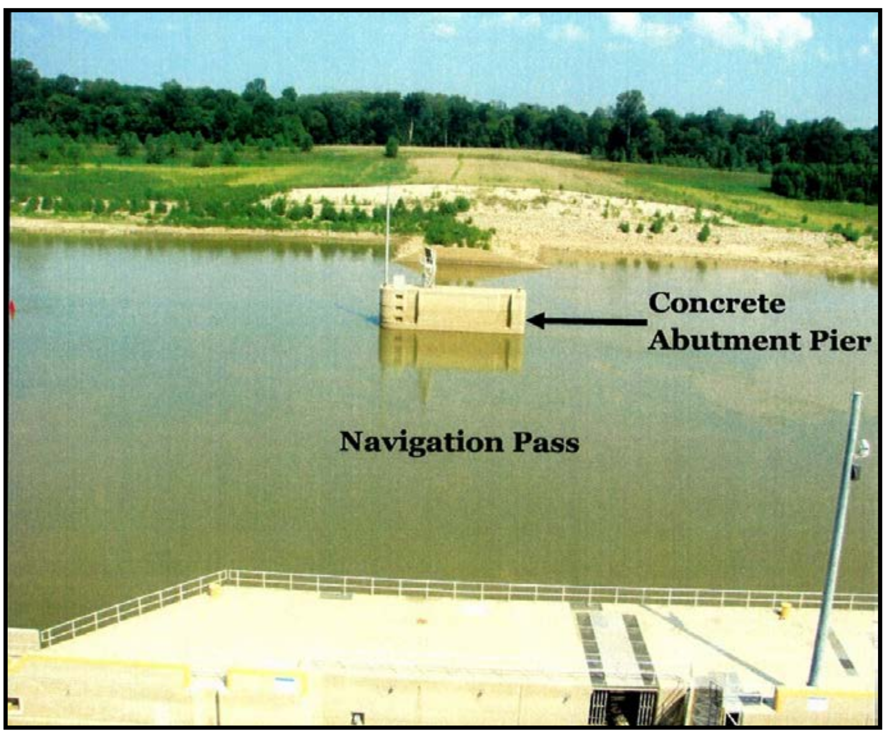
It is apparent that the flow exiting the bend at RM 1.0 was only slightly influenced by the weirs and split near the floating [guide] walls. The weirs do not have much of an effect on the flow because they have minimal section (approximately 5 ft) and are at an angle perpendicular to the bank line and the lock and dam. Generally weirs are angled such that the end of the weir in the channel is upstream of the portion of the weir tied into the bankline. The upstream angled weirs disperse high velocities across its section and direct some flow towards the inside of the bend or channel (Cox et al. 2011).

Because most of the energy is directed towards the LDB, during high water tows are pulled toward the navigation pass pier. As a result of the split flow at the [guide] wall, an eddy forms near the RDB, [guide] wall, and miter gate. The flow directed towards the eddy is still strong enough to influence tows in that direction as well. During high water, flows rushing under the [guide] wall towards the LDB have been strong enough to slightly twist the floating [guide] wall. Overall, the flow just upstream of the lock has been extremely difficult to predict, and as a result, conditions have been difficult to navigate (Cox et al. 2011).

Five significant allisions[1] have occurred since opening the lock on 24 August 2004.

For most of the year, MPLD operates at open river with all of the gates down and tows utilize the navigation pass [Figure 16]. The gates are raised and the lock chamber used by tows (i.e., pool condition) when the tailwater of MPLD falls to an elevation of 115 ft National Geodetic Vertical Datum of 1929 (NGVD29) [Figure 17]. The tailwater elevation is controlled by the Mississippi River. The Montgomery Point upper pool must be operated within the limits of 115 to 119 ft NGVD29. The upper limit of the pool is derived from the elevation of a raised gate at 115 ft NGVD29, and the design maximum allowable head over the top of a raised gate at approximately 4 ft (Cox et al. 2011).

Figure 16. Hinged crest gates of the navigation pass lying flat on river bottom at high water on the Mississippi River. Tows travel through open river navigation pass at high water. Note concrete abutment pier.



[1] In the context of maritime law, the term *allision* means the act of a moving vessel striking against a stationary object. Allision is different from collision. The term *collision* signifies the running of two vessels against each other. (http://definitions.uslegal.com/a/allision/)

Figure 17. Hinged crest gates in raised position to create navigation pool upstream of MPLD at low water on the Mississippi River. Tows travel through the lock at low water.

To operate within pool limits, the Mississippi River elevation controls the position of the gates and the White River flow controls the number of gates raised. For example, when White River flow is approximately 19,000 cubic feet per sec (cfs), all 10 gates are raised in order to maintain a pool elevation of 119 ft NGVD29. However, if flow on the White River is approximately 53,000 cfs, only 5 gates are raised to maintain a pool elevation of 119 ft MSL. The lock chamber miter gates can only open when the river elevation is below 127 ft MSL (Cox et al. 2011).

Fletcher and de Bejar (1995) had previously conducted a physical model study of the hydraulic forces acting on the MPLD navigation pass spillway gates, and concluded the following:

> Water levels fluctuate greatly at the site (68 ft from a recorded low elevation 104, to flood of record elevation 172). At some point during the design life of the project, the tailwater is expected to drop as low as elevation 95 ft. The gates will remain in the raised position during operations to control upper pool until the tailwater is again at elevation 115 and rising. At that point the gates will be lowered. During periods of controlled flow through the navigation pass, and

during periods of gate maintenance, all navigation will be conducted through the lock chamber (Fletcher and de Beejar 1995).

Figure 18 shows a tow entering the navigation lock moving upstream at low water. Figure 19 shows a tow entering the navigation pass moving upstream at higher water with a larger tow traveling on the Mississippi River in the background.

The entire MPLD complex is built below the White River bank line, except the control tower. At extreme high water on the Mississippi River, the entire MPLD complex will become submerged, except the control tower (Figure 20). The concrete navigation pass abutment pier (Figure 21) may then become a hazard to navigation. Figure 22 shows a tow boat sitting on top of the pier after an allision on 11 February 2005, shortly after MPLD was placed into service 24 August 2004. Since the opening of the lock, there have been at least five significant allisions.

Figure 18. Barge tow entering MPLD navigation lock heading upstream at low water.

Figure 19. Barge tow entering MPLD navigable pass heading upstream at high water while a larger tow passes on the Mississippi River.

Figure 20. At higher water, the entire MPLD complex becomes submerged, except for the control tower and the lock guide walls abutment piers.

Figure 21. Navigation pass concrete abutment pier may become a hazard at high water.

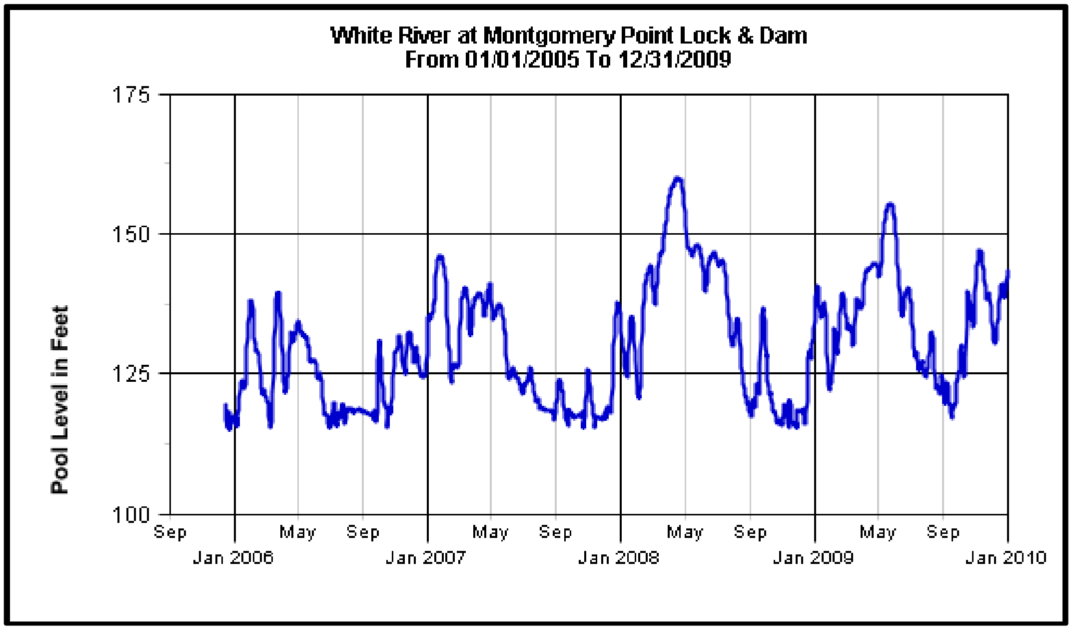
Figure 22. Tow boat allision with navigable pass concrete abutment pier at high water.

4 Data Collection and Results

Objectives of this monitoring effort at MPLD included assessing whether the project was functioning as designed with regards to navigation and channel development. Another objective was to determine loads or vibrations on the hinged crest torque-tube gates and apply knowledge gained to projects with similar gates.

Pool elevations NGVD29 at MPLD for period 1 January 2005 through 31 December 2009 are shown in Figure 23.

Figure 23. Pool elevations at MPLD.



Scour hole downstream of overflow spillway and navigation pass

Bathymetric survey data were collected using a 200 Khz single beam echo sounder. The bathymetric surveys for May 2008 and June 2009 are shown in Figures 24 and 25, respectively. Figure 24 (May 2008 survey) shows a deeper area in the channel bathymetry just downstream of the stone protection of the navigable pass stone and north of the lock stone protection to about elevation 68 ft NGVD29 when compared to the surrounding area at elevation 75 to 80 ft NGVD29.

Figure 24. May 2008 bathymetric survey, White River, vicinity of MPLD, high water, pool elevation approximately 150 ft NGVD29. Scour hole bottom elevation approximately 68 ft NGVD29.

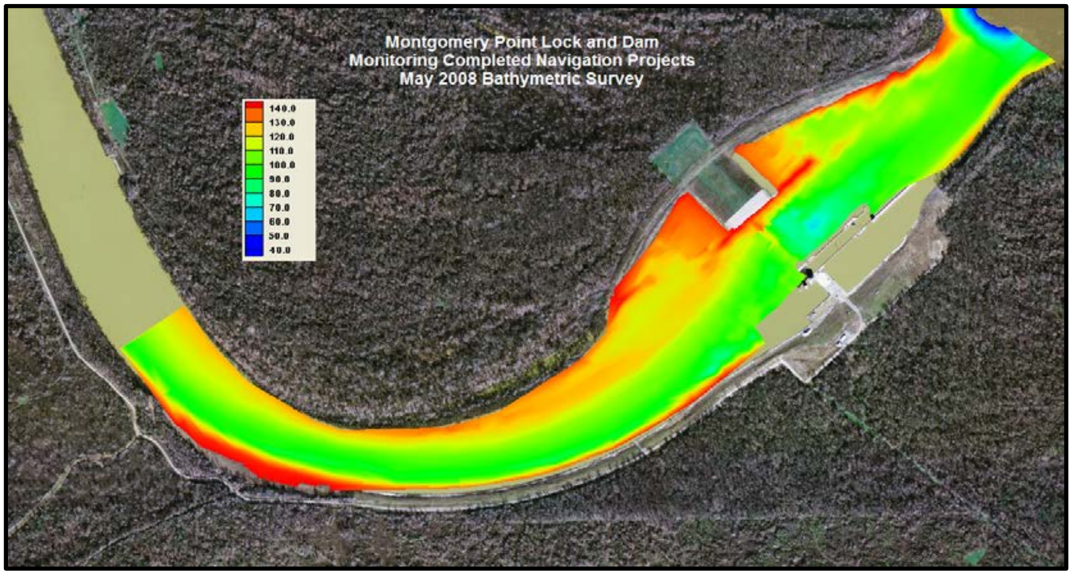


Figure 25. June 2009 bathymetric survey, White River, vicinity of MPLD, high water, pool elevation approximately 148 ft NGVD29. Scour hole bottom elevation approximately 45 ft NGVD29.

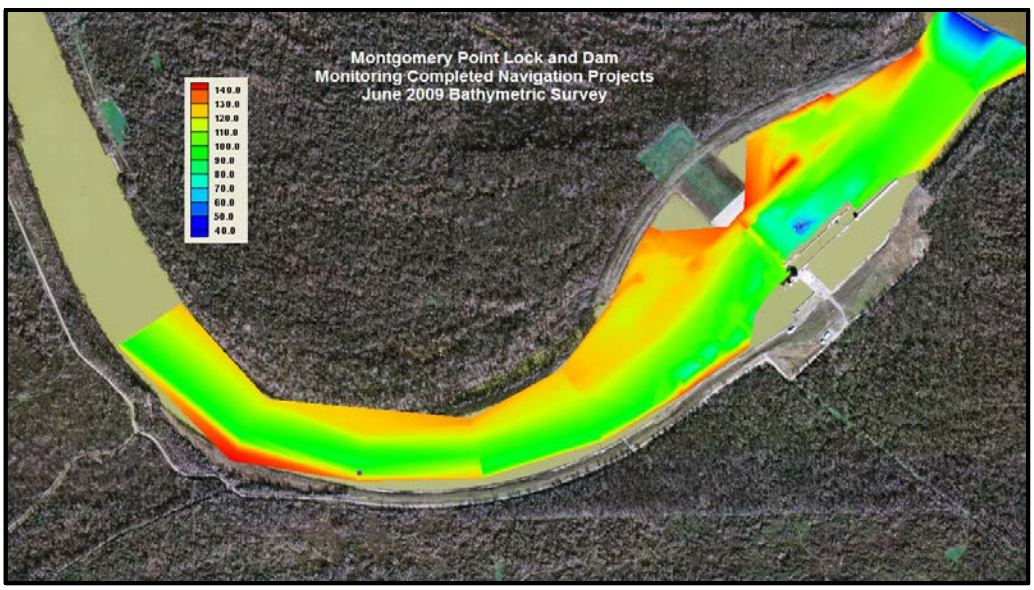


Figure 25 (June 2009 survey) shows additional deepening and widening in the area just downstream of the stone protection of the navigable pass stone and north of the lock stone protection to approximately elevation 45 ft NGVD29.

Closeup views of the bathymetric surveys in the vicinity of MPLD for May 2008 and June 2009 are shown in Figures 26 and 27, respectively. A difference map showing the change in bathymetric elevation between these two survey dates is shown in Figure 28.

Figure 26. Closeup view of scour hole bathymetry downstream of MPLD navigation pass, May 2008. Scour hole bottom elevation approximately 68 ft NGVD29.

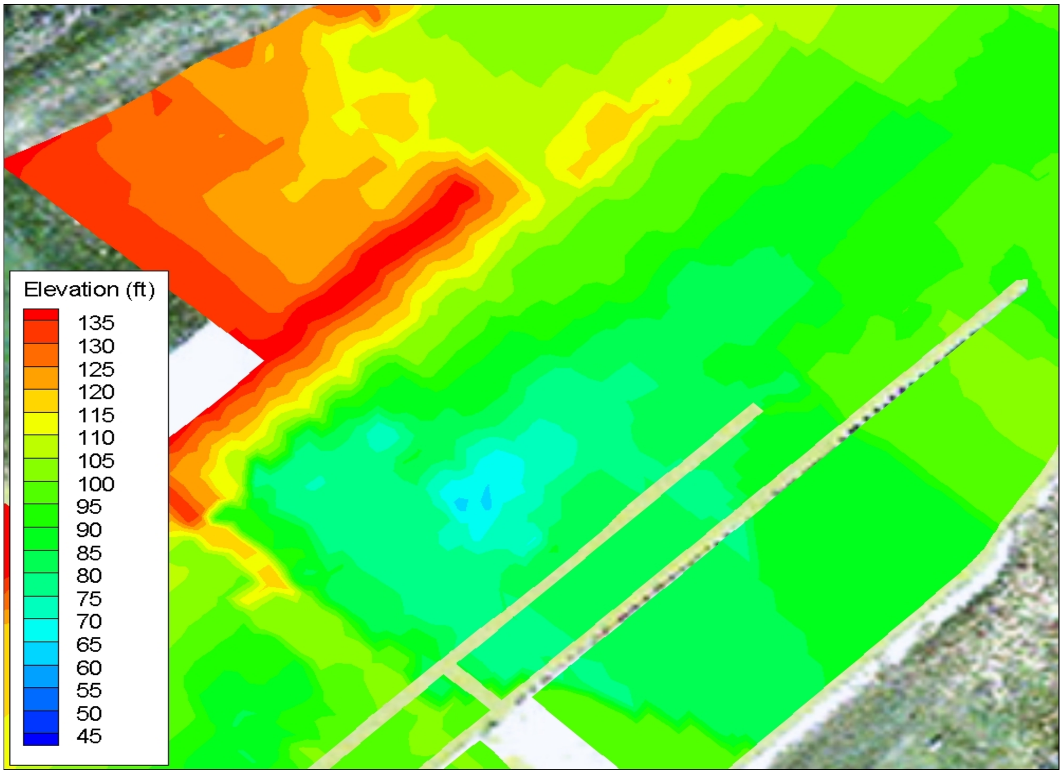


Figure 27. Closeup view of scour hole bathymetry downstream of MPLD navigation pass, June 2009. Scour hole bottom elevation approximately 45 ft NGVD29.

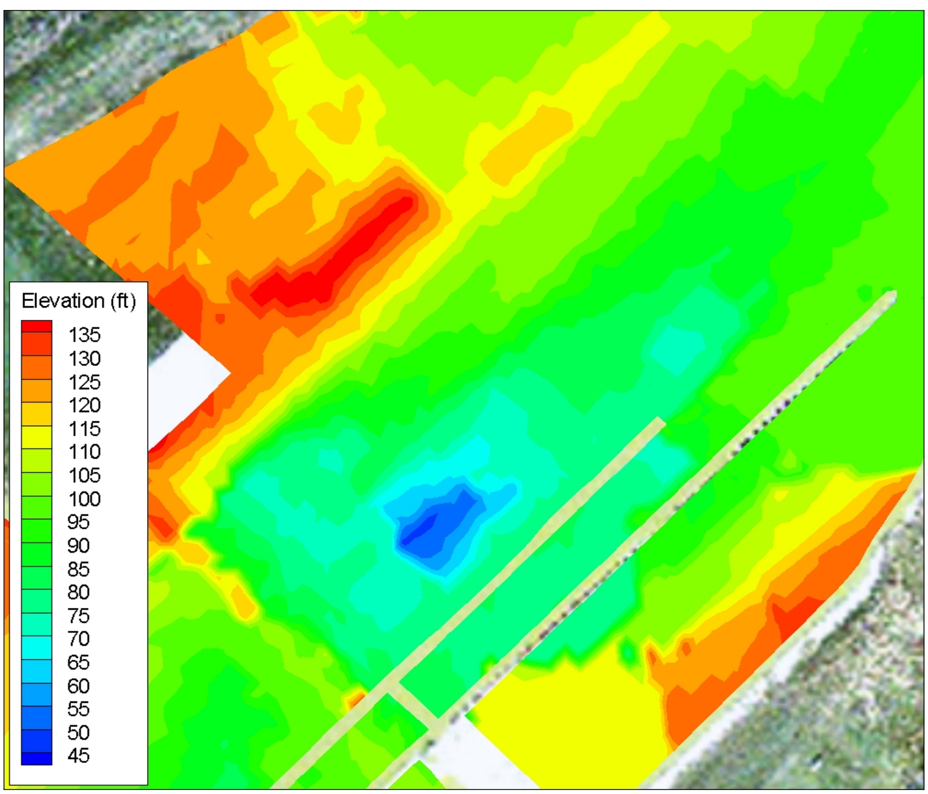
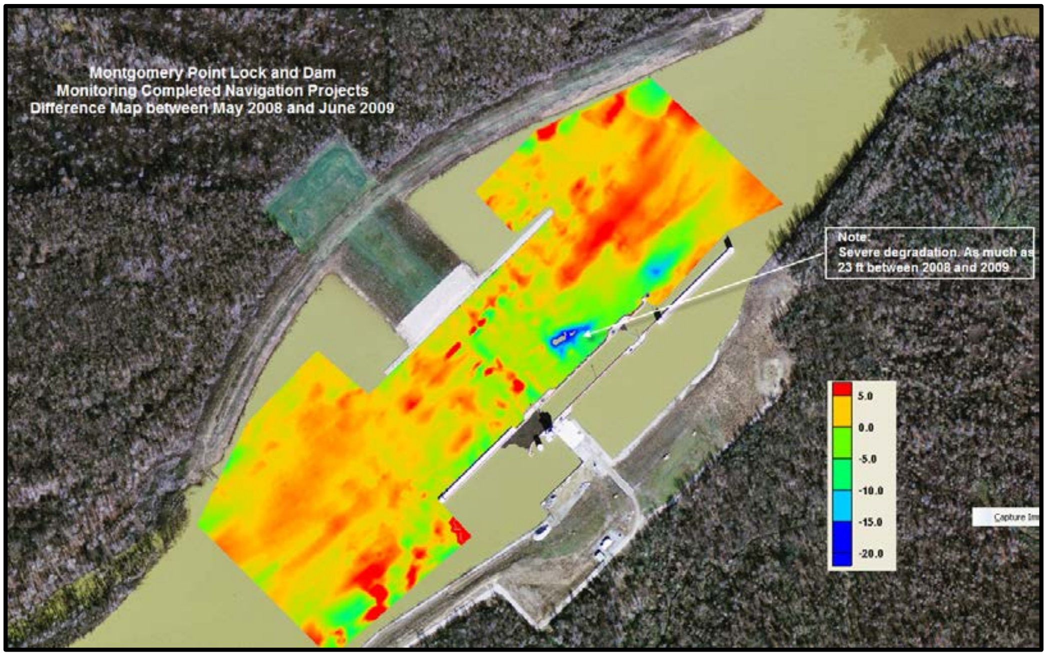


Figure 28. Difference map showing change in channel elevation between May 2008 and June 2009, vicinity of MPLD. Up to 23 ft of additional degradation occurred in scour hole below navigation pass during this time period.



Himstedt (2015, personal communication) stated that dredged material had been placed in the scour hole in 2007 and covered with four work-barge loads of stone, although the stone size was not available. The difference map between the May 2008 and June 2009 surveys (Figure 28) showed significant degradation and widening of the area just downstream of the stone protection of the navigable-pass stone and north of the lock stone protection. This comparison showed approximately 23 ft of additional degradation in this area, with more degradation farther downstream along the lock. The scour hole appeared to have widened and lengthened quite significantly during this time period. The scour hole was approximately 115 ft wide and 260 ft long, according to the survey of June 2009.

The scour hole developed at this specific location because river flow at high water over the fixed-bed navigation pass is analogous to high-velocity turbulent flow over a weir. The resulting high-velocity currents provide forces capable of scouring the movable bed material comprising the river bottom in this vicinity. Based on these survey data showing significant scour hole enlargement between May 2008 and June 2009, it was recommended that SWL fill and stabilize the scour hole with stone sufficiently large enough to prevent scour hole enlargement with resulting potential endangerment of the navigation structures.

Sedimentation and deposition upstream of navigation pass

Figures 29 and 30 are close-up views of the bathymetry surveys of the upstream approach to the lock and navigation pass for May 2008 and June 2009, respectively. A difference map showing the change in bathymetric elevations between these two surveys is shown in Figure 31.

The differences in elevation between May 2008 and June 2009 at these upstream approaches to the lock and navigation pass were insufficient to impede barge traffic, being only approximately 4–6 ft in very small areas of that reach of the waterway (Figure 31). No maintenance channel dredging was required because these small sections of deposition would be easily obliterated by propeller wash.

Figure 29. Close-up view of bathymetry of the MPLD upstream lock approach, May 2008.

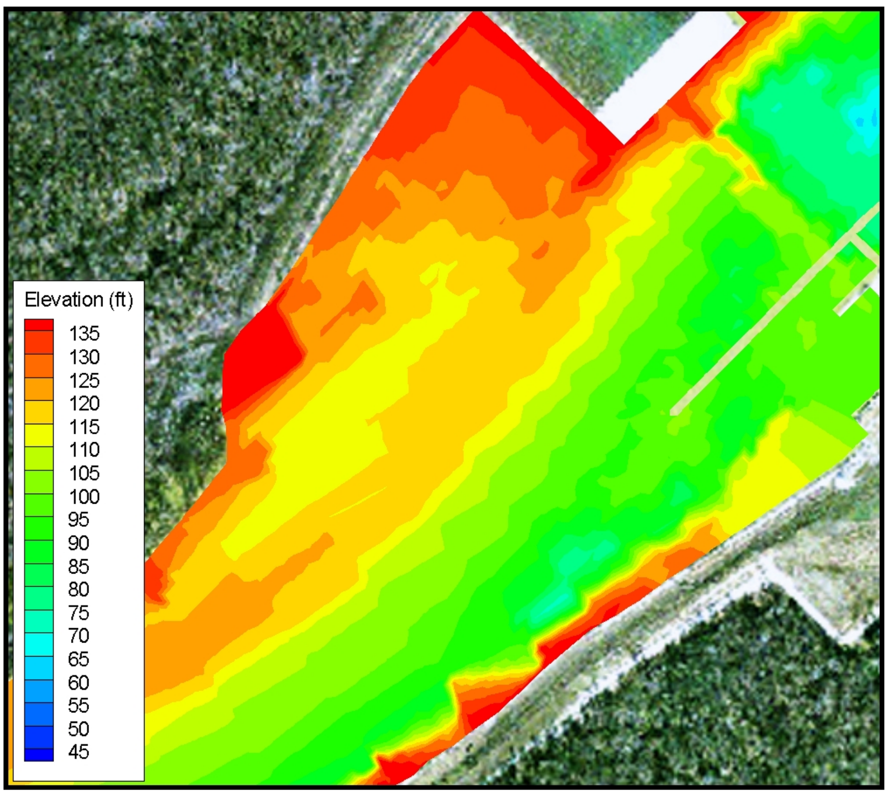


Figure 30. Close-up view of bathymetry of the upstream lock approach, June 2009.

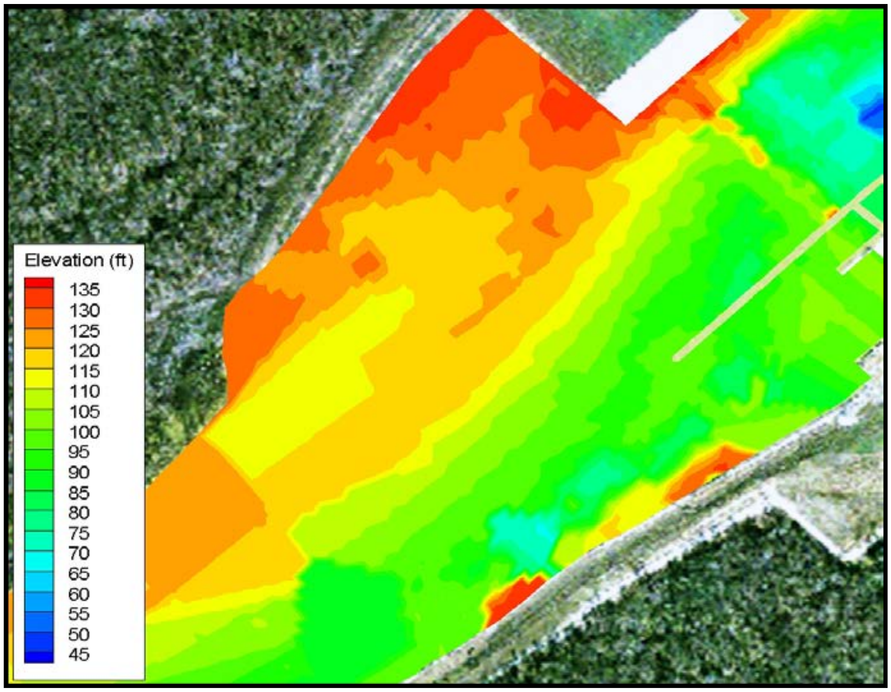
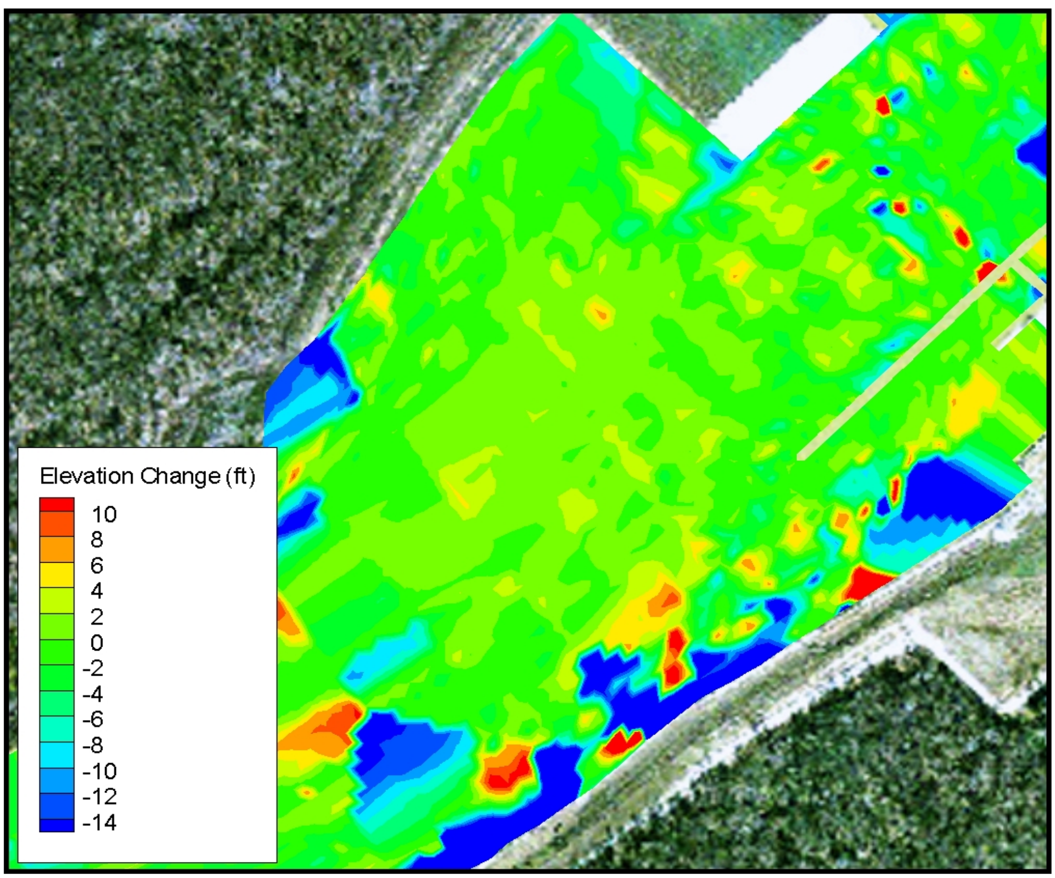


Figure 31. Difference map showing change in upstream lock approach channel elevation between May 2008 and June 2009, vicinity of MPLD.

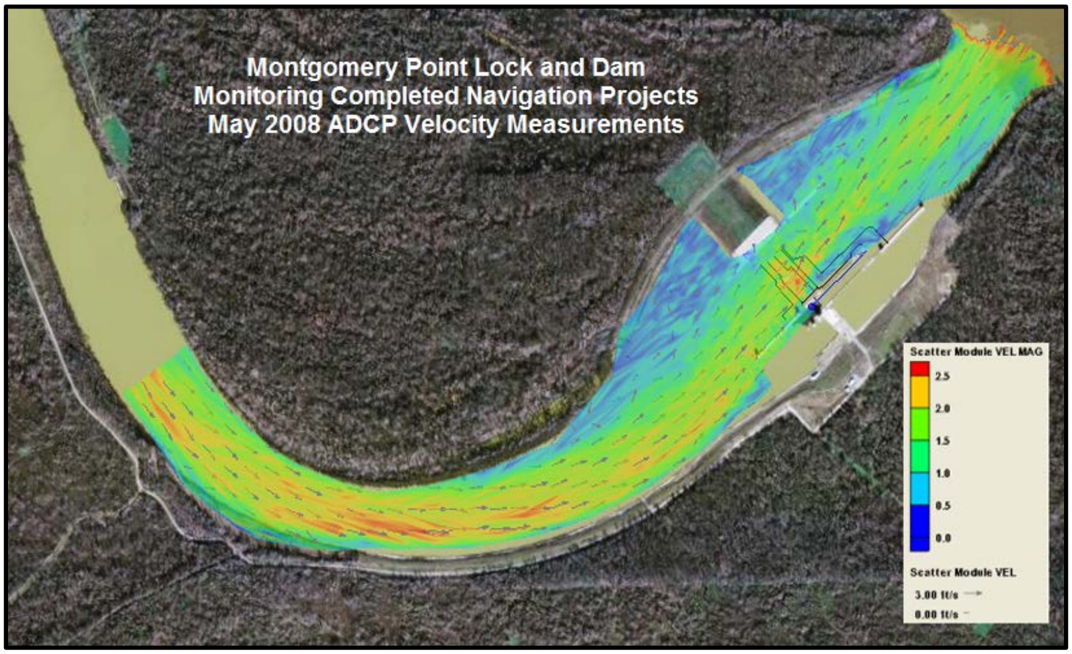


Lock and navigation pass upstream approach velocity conditions

Discharges and velocities

Discharge measurements were collected in May 2008 and June 2009 using an ADCP. Current magnitudes and directions were extracted from the discharge measurements to produce the flow field for both surveys. These data were used to compare with data collected in the physical model. Figure 32 shows the flow field during the May 2008 data collection effort.

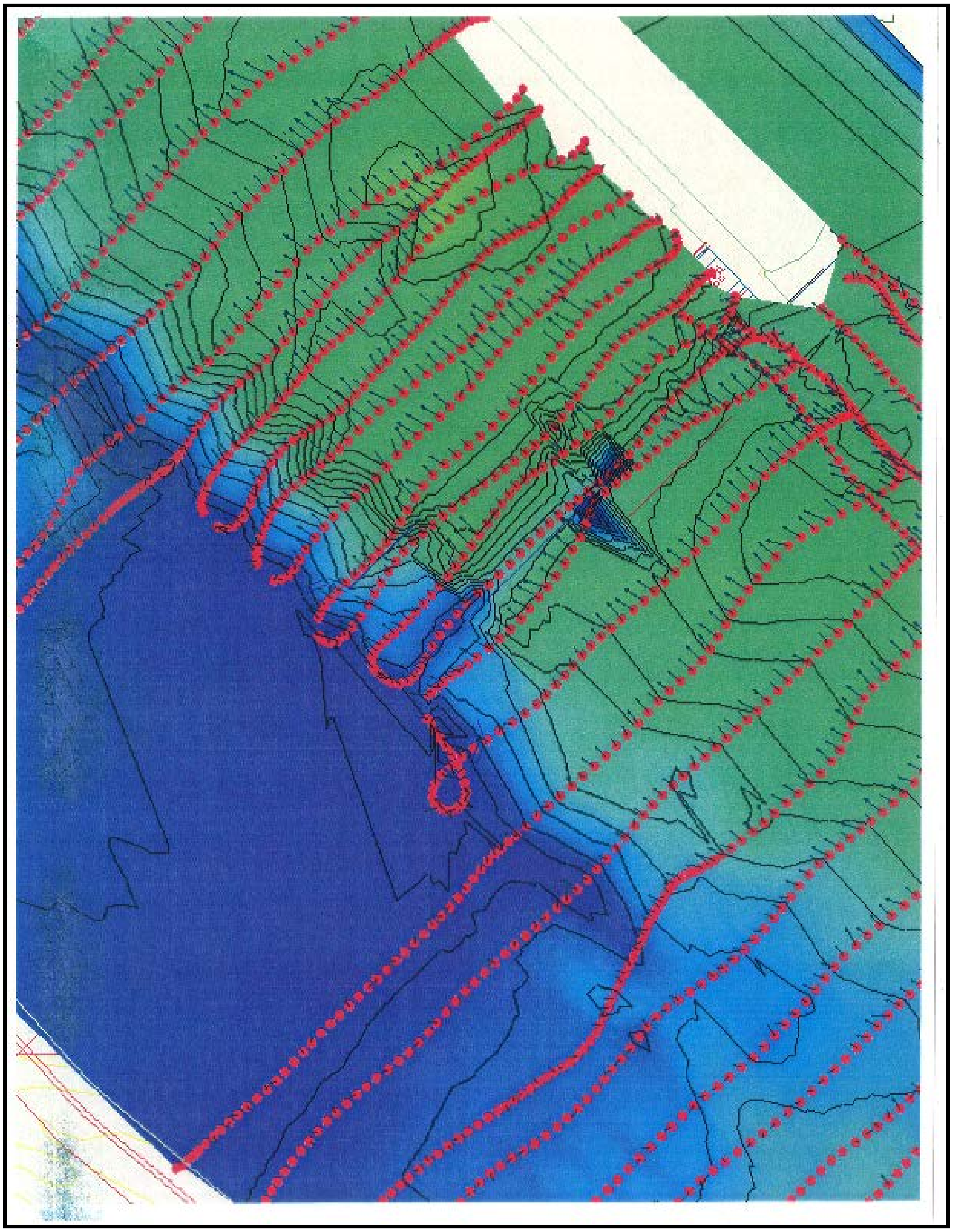
Figure 32. May 2008 ADCP velocity measurements.



The ADCP discharge measurement for the May 2008 survey was approximately 57,000 cfs at a water level approximately 148.0 ft NGVD29. Current magnitudes and direction data obtained from the ADCP data indicated that flow was concentrated along the RDB in the bend upstream of the lock and into the upper lock approach. Current magnitudes ranged from 2.0 to 2.5 fps in these areas. Once past the upper lock approach, the flow through the navigable pass tended to be concentrated toward the left end of the navigable pass in the vicinity of the pier separating the navigable pass and overflow weir. Large, slow-moving eddies with current magnitudes of 0.5 to 1.0 fps were observed upstream and downstream of the dam along the right bank.

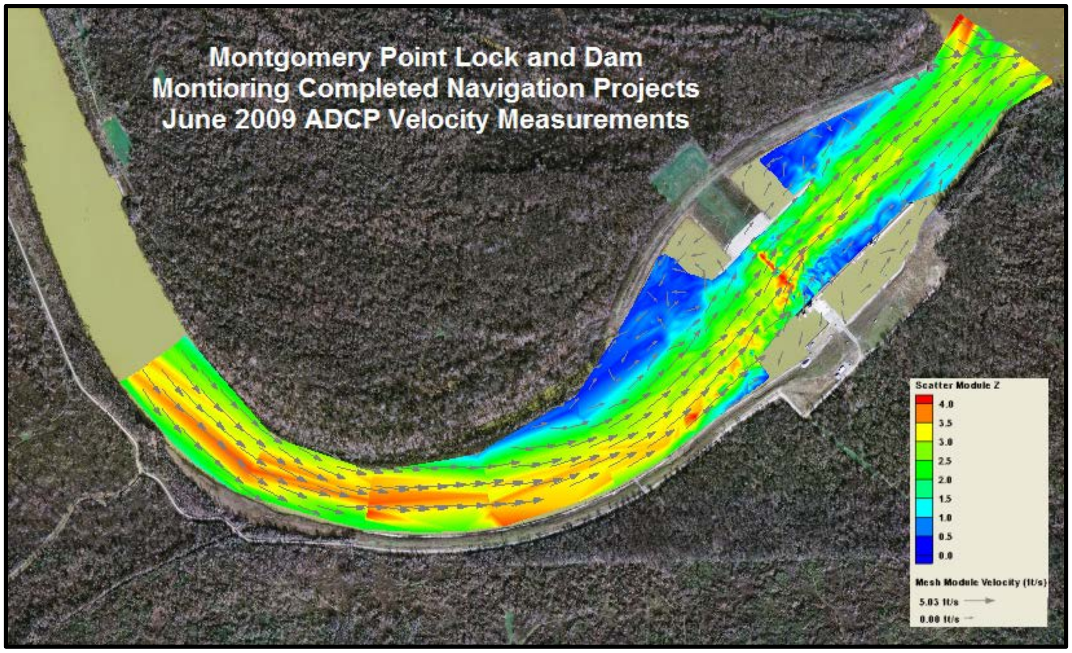
Figure 33 shows a typical example of the density of the ADCP field data.

Figure 33. Typical example of density of the ERDC ADCP field survey velocity and discharge data acquisition.



The flow field for the June 2009 survey is shown in Figure 34.

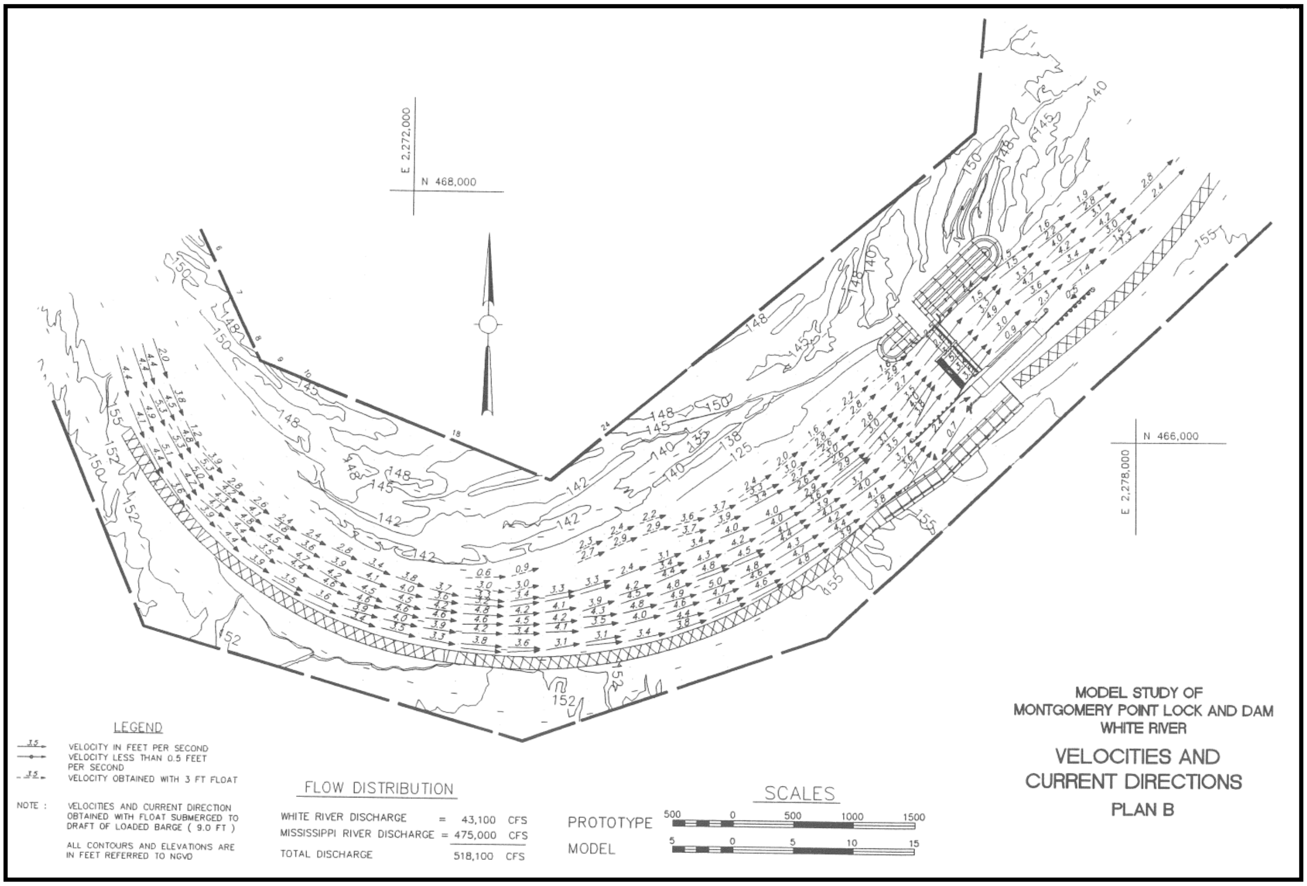
Figure 34. June 2009 ADCP velocity measurements.



The ADCP discharge measurement for the June 2009 survey was approximately 80,000 cfs and a water level approximately 148.0 ft NGVD29. Current magnitudes and direction data obtained from the ADCP data indicate the same trend as those observed in the May 2008 survey; however, current magnitudes were greater and ranged from 3.0 to 3.5 fps. This should be expected since the discharge was greater and the water level was the same. Current magnitudes through the navigable pass and the overflow weir were approximately 4.0 fps. Large, slow-moving eddies with current magnitudes of 0.5 to 1.0 fps were also observed upstream and downstream of the dam along the right bank.

Figure 35 shows the physical model current magnitude and direction data collected with a similar plan as shown in Figures 32 and 34 but with a White River discharge of 43,100 cfs and a tailwater elevation of 125.0 ft. There were no data collected in the physical model precisely for the discharges and tailwater elevations observed in the May 2008 and June 2009 surveys. However, flow patterns can be compared. The ERDC physical hydraulic model indicated flow patterns very similar to those observed with the prototype data collected in May 2008 and June 2009 surveys. The physical model also indicated a concentration of the flow toward the RDB upstream of the lock and into the upper lock approach. The flow then moved under the floating guide wall, around the lock, and over the navigable pass and overflow spillway. The physical model data also indicated that the flow is directed toward the left bank and the pier separating the overflow spillway and navigable pass. No precise comparison could be made in current magnitude between the prototype and the ERDC physical model due to slight differences in discharges and tailwater elevations.

Figure 35. ERDC physical model results: White River discharge = 43,100 cfs; tailwater elevation = 125.0 ft.



The echo-sounder bathymetric and ADCP velocity field data obtained by ERDC in May 2008, September 2008, and June 2009, and similar bathymetric and velocity field data obtained by SWL in June 2010, were transmitted by SWL to USACE AREC for additional analyses and interpretation. The AREC displays of the ERDC and the SWL ADCP channel velocities for these four time periods are shown in Figures 36 through 39. AREC described the display technique as follows:

> A comparison of velocity distribution using several cross sections of the channel was necessary to evaluate and compare flow trends. In order to compare the general velocity trends between the river and [AREC micro-] model [AREC micro-model results are not reproduced in this ERDC document], the velocities in each cross

section were normalized. Normalization involved dividing the magnitudes from each transect by the highest magnitude in that particular transect. This created a velocity scale from 0 to 1 for both the collected river ADCP [ERDC and SWL river ADCP data as interpreted by AREC are reproduced in this ERDC document by permission, Figures 36 through 39] and the [AREC micro-] model LDV data [AREC micro-model results are not reproduced in this ERDC document]. The normalized data showed the magnitude distribution between the highest and lowest velocities in each cross section. The direction was unchanged, and showed directional issues like eddies and outdraft (Cox et al. 2011).

Conclusions from the velocity displays of Figures 36 through 39 by AREC include the following by Cox et al. (2011):

- "River Miles 4.0 – 3.7: The higher energy of the river was located near the RDB."
- "River Miles 3.7 – 2.6: The highest velocities crossed to the LDB. Around RM 3.1, the highest velocities deflected off the LDB and stayed toward the middle of the channel."
- "River Miles 2.6 – 2.2: The higher energy of the river was forced to the RDB by the kicker dike at RM 2.3."

Figure 36. ERDC ADCP velocity data, May 2008. Normalized and interpreted by USACE AREC (Plate 23 of Cox et al. 2011; by permission).

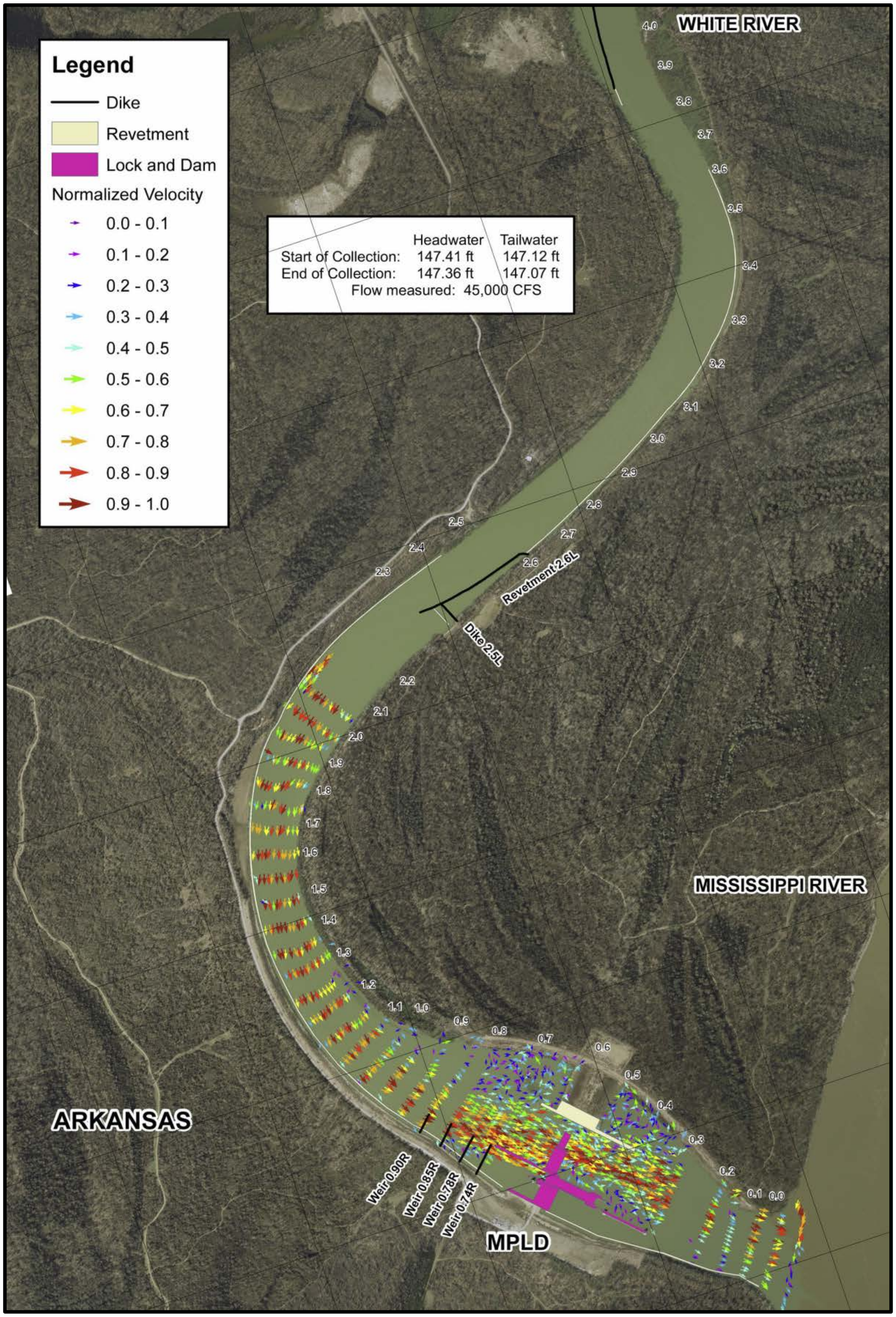


Figure 37. ERDC ADCP velocity data, September 2008. Normalized and interpreted by USACE AREC (Plate 24 of Cox et al. 2011; by permission).

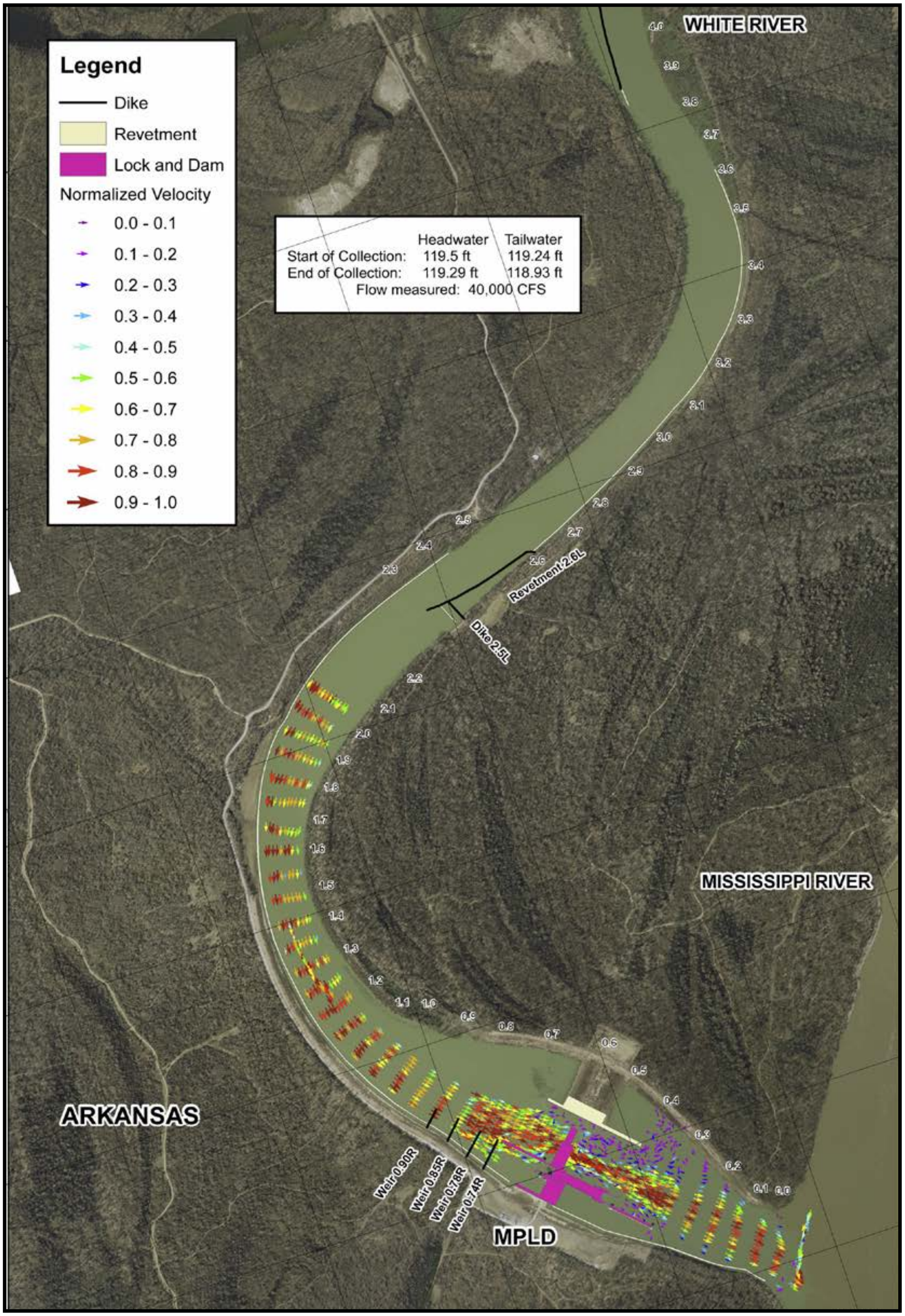


Figure 38. ERDC ADCP velocity data, June 2009. Normalized and interpreted by USACE AREC (Plate 25 of Cox et al. 2011; by permission).

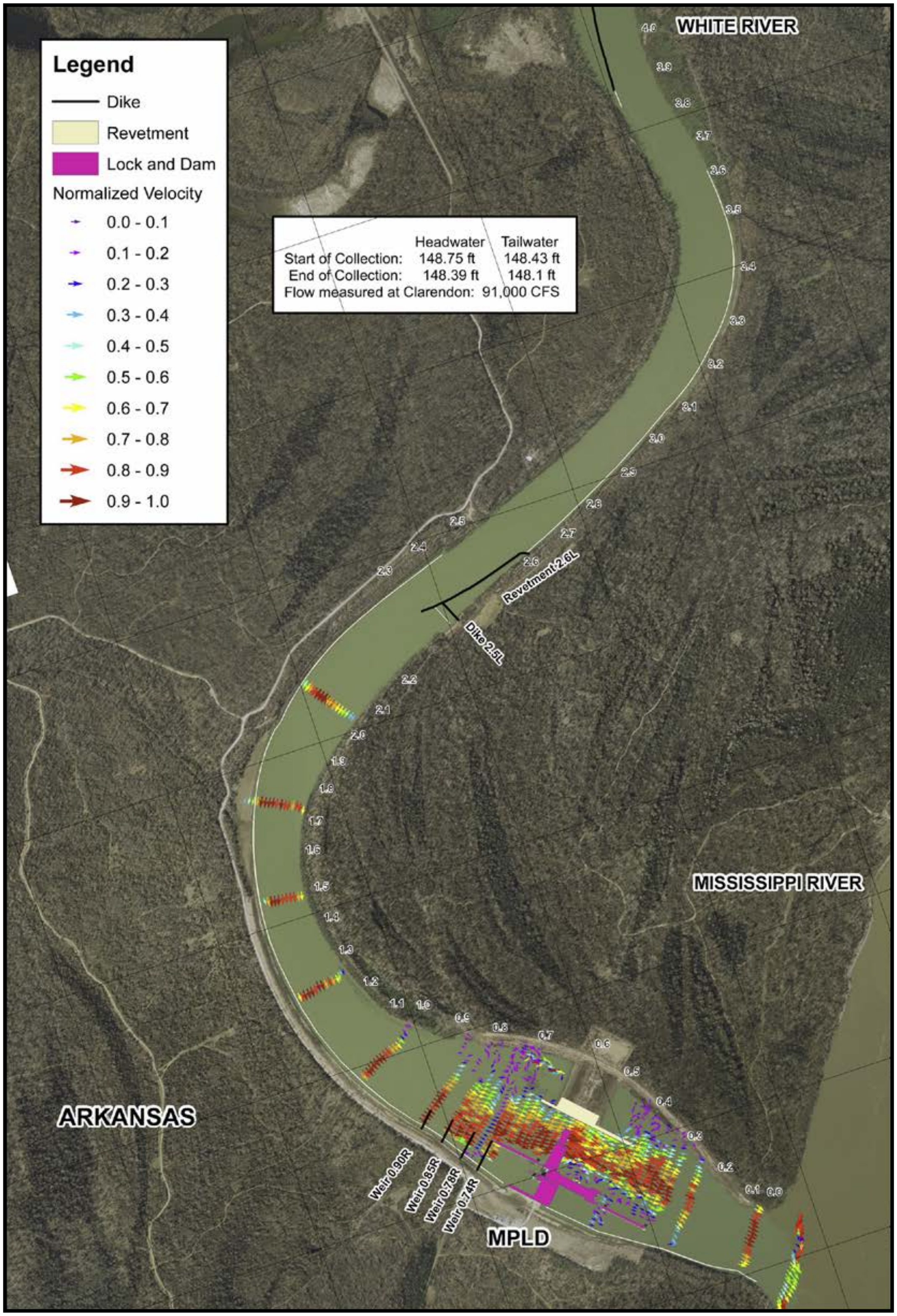
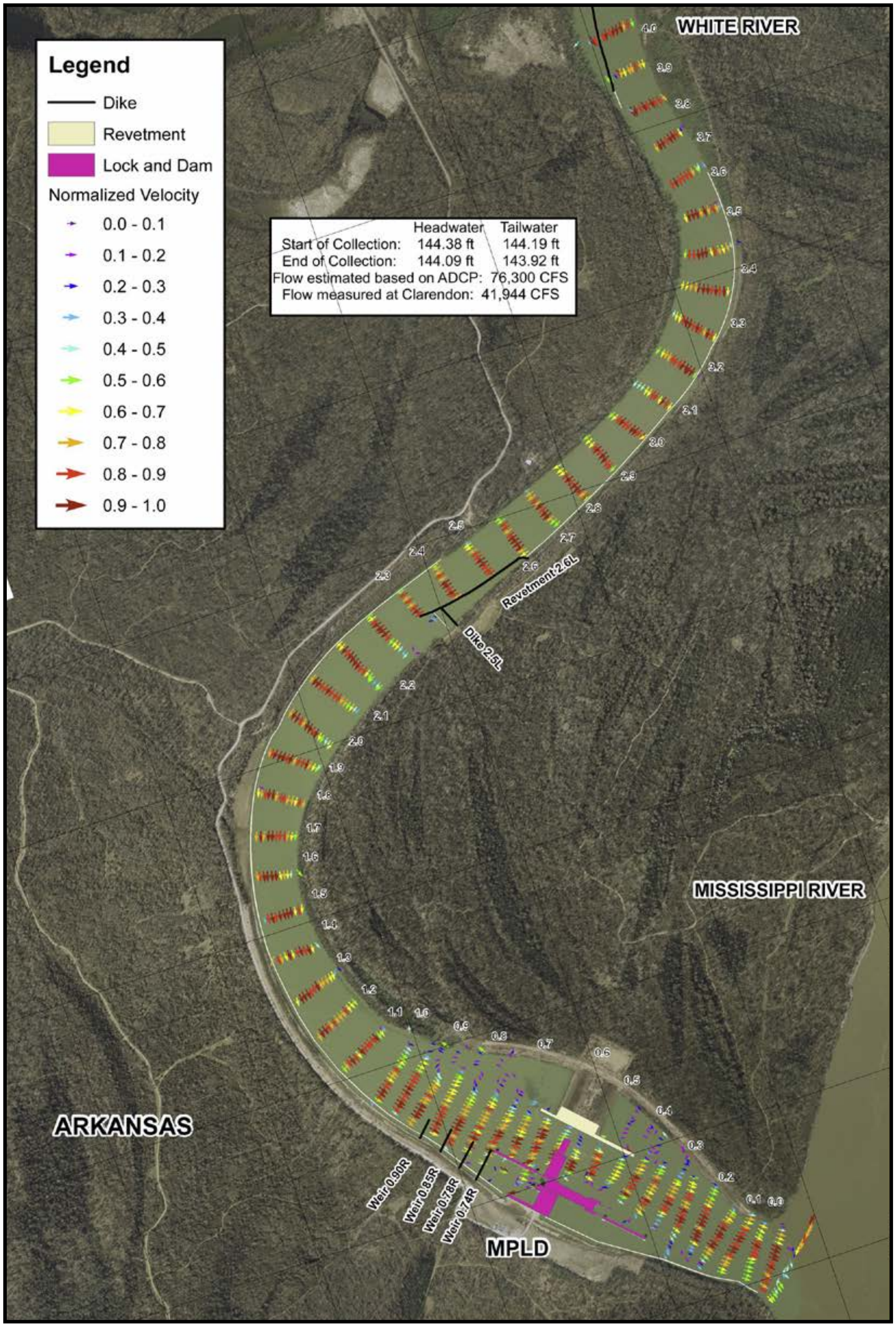


Figure 39. SWL ADCP velocity data, June 2010. Normalized and interpreted by USACE Applied River Engineering Center (Plate 26 of Cox et al. 2011; by permission).



- “River Miles 2.2 – 0.74: The highest velocities deflected off the RDB near RM 1.7 and migrated near the LDB at RM 1.5. The higher energy dissipated slightly, but velocities increased again near RM 1.0 on the RDB. After the first weir, the direction of flow was altered and the slightly higher velocities stayed toward the middle of the channel, while the slightly slower velocities stayed near the RDB side and the lock. In the slack water on the LDB from RM 1.0 – 0.74, there was a weak eddy.”
- “River Miles 0.74 – 0.6: Slower velocities on the RDB created an eddy between the RDB, floating guide wall, and closed lock gate. Velocities also moved underneath the guide wall. The higher velocities were slightly angled towards the LDB, increased by the flows coming underneath the guide wall. At the navigation pass, high velocities were directed toward the navigation pass pier.”
- “River Miles 0.6 – 0.0: After the spillway, the main energy stayed in the middle of the channel from RM 0.6 – 0.0. A small eddy developed in the slack water behind the earthen dam from RM 0.6 – 0.25. At RM 0.1 to 0.0 velocities increased near the RDB.”

Tow time-lapse videos and AIS

There have been five significant allisions since the lock was opened, such as the barge striking the navigation lock wall in January 2010 (Figures 40 and 41). Figure 42 shows the upstream lock guide wall that is also subject to allisions. Time-lapse video equipment was installed at the project to observe tows transiting via the navigable pass or the lock under outdraft conditions and redirected currents toward the navigable pass.

The time-lapse video equipment installed at Montgomery Point Lock and Dam consisted of two digital cameras in a weather-proof case, one looking upstream and one looking downstream. The cameras were connected to a digital time-lapse video recorder (DVR) installed in the lock operation building. The DVR was capable of recording multiple camera inputs at 120 frames per second for an extended period of time. The digital video was retrieved, extraneous information was removed, and the video was analyzed. Figures 43 and 44 show the time-lapse video installation.

Figure 40. Barge damage after allision with MPLD navigation structure, January 2010.

Figure 41. MPLD navigation lock parapet wall damage after being struck by barge, January 2010.

Figure 42. MPLD upstream navigation pass floating guide wall subject to allisions.

Figure 43. Time-lapse digital video recorder installation.

Figure 44. Example of surveillance camera in waterproof enclosure.

The collection of time-lapse video information (examples shown in Figures 45 through 48) would allow project personnel to retrieve the video and observe how vessels had transited the lock or navigable pass, coupled with the flow conditions at the time of the transit. Also, in case of an accident, provided the vessel was in view, judgment as to what may have caused such an accident could be deduced. No untoward barge vessel incidences occurred during the 1-year time interval (January–December 2011) when the video cameras were in place at MPLD.

AIS instrumentation was also installed at MPLD. The AIS provides information to the lock such as vessel name, cargo being carried, estimated time of arrival, speed over ground, heading, etc. Information such as speed and heading available through the AIS database can be used to produce general tow track plots of vessels transiting the locks or navigable pass. Such data are essential for recreating navigation hazard incidences but were not required during this time period as no adverse impacts occurred.

Figure 45. Looking upstream; downbound tow transiting navigable pass.

Figure 46. Looking downstream; same downbound tow as shown in Figure 45 transiting the navigable pass and proceeding to the Mississippi River.

Figure 47. Looking downstream; upbound tow entering the White River and proceeding upstream through the navigable pass.

Figure 48. Looking upstream; same upbound tow as shown in Figure 47 transiting the navigable pass and proceeding upstream on the White River.

Spillway gate leakage

Spillway gate leakage could only be measured when the tailwater elevation recedes to 115 ft NGVD29 (low water) and the gates are in a raised position. Discharge would be inferred by taking ADCP velocity measurements across the water column and integrating over the cross-sectional area to obtain quantity of spillway gate leakage.

The pool elevation was at high water all three time periods when ERDC conducted field surveys: (1) May 2008, elev. = 150 ft NGVD29, (2) September 2008, elev. = 125 ft NGVD29, and (3) June 2009, elev. = 135 ft NGVD29 (Figure 23). The gates were not in a raised position during the time of any of these ERDC field surveys. A necessary prerequisite for measuring spillway gate leakage and verifying the physical model estimates was that the gates must be in a raised position. Hence, it was not possible to accomplish this element that was originally scheduled to be monitored.

Forces on crest gates

Ten 30 ft wide, bottom-hinged, torque-tube crest gates (Figures 49 and 50) are positioned across the navigation pass. Figure 51 shows the MPLD navigation pass crest gates in service. They are raised and lowered by hydraulic cylinders located in a concrete tunnel underneath the navigation pass (Figures 52 through 55).

Figure 49. One of 10 MPLD navigation pass crest gates in raised position, looking upstream.

Figure 50. Four of 10 MPLD navigation pass crest gates in raised position, looking downstream.

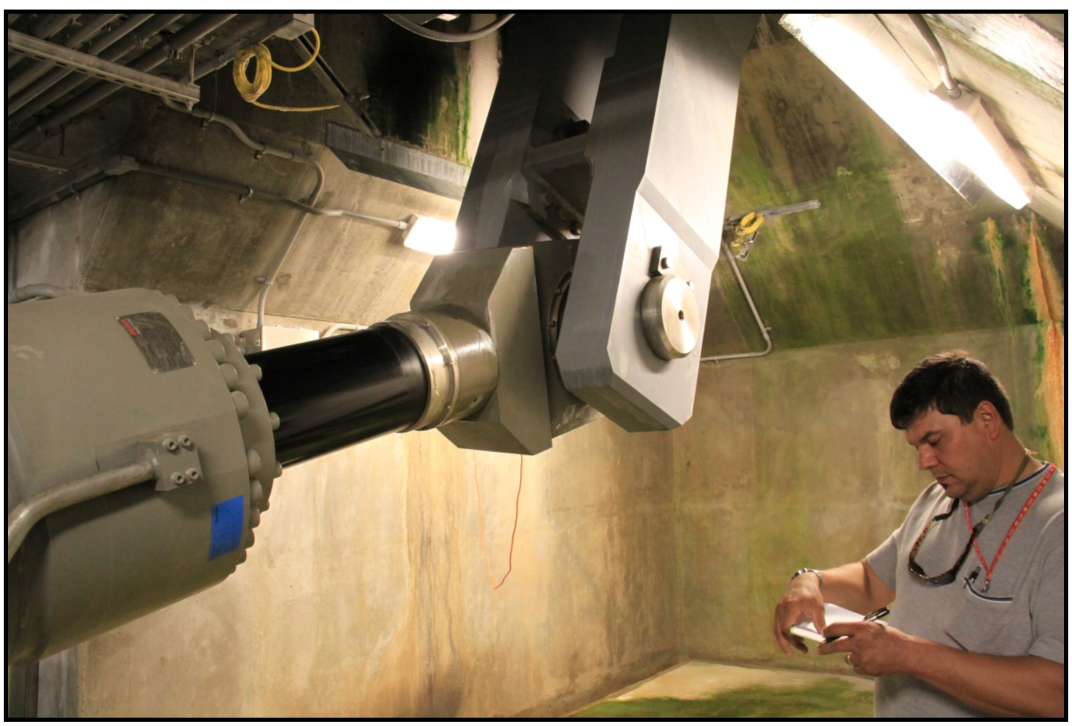
Figure 51. MPLD navigation pass crest gates in service.

Figure 52. Concrete tunnel beneath navigation pass from which hydraulic cylinders raise and lower crest gates.

Figure 53. Hydraulic cylinder which raises and lowers one of the 30 crest gates under the navigation pass at MPLD.

Figure 54. Hydraulic cylinder ram attached to gate strut mechanism.

Figure 55. Gate strut mechanism.



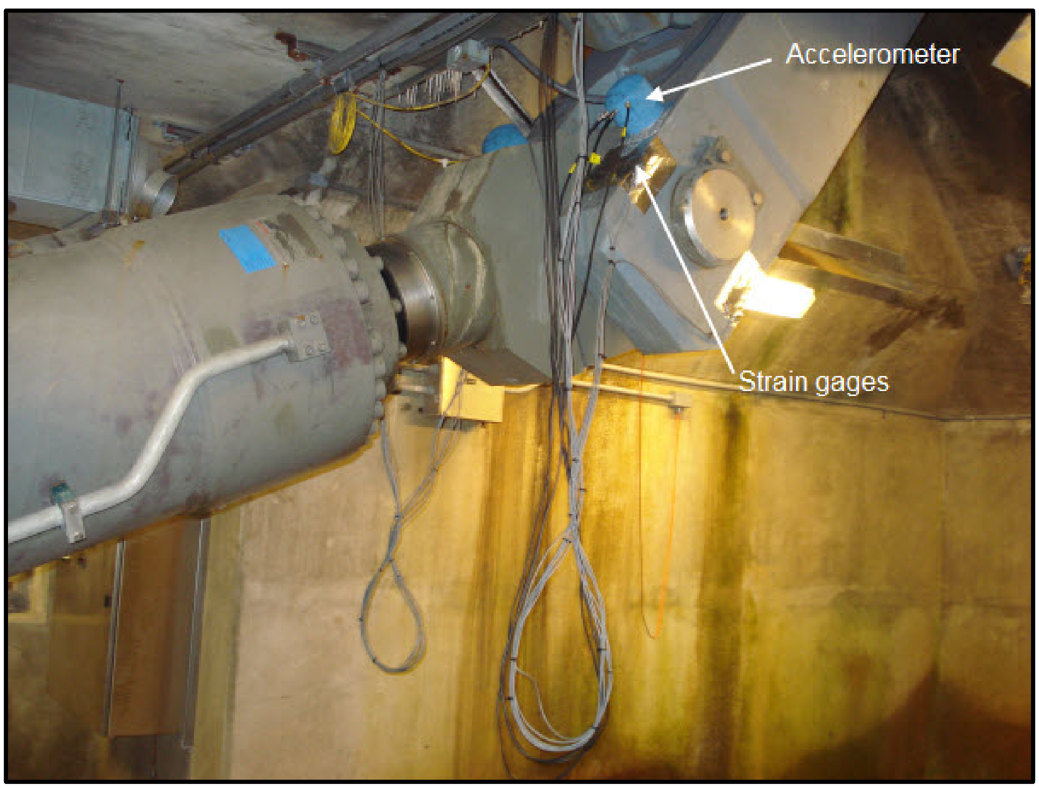
Strain gages and accelerometers were placed on gate struts located in the galley of the dam to monitor the activity of the bottom-hinged, torque-tube crest gate during operation and while the gates were in the raised position. Figure 56 shows an accelerometer, and Figure 57 shows two strain gages attached to the gate mechanism. Figure 58 shows the location of both the accelerometer and the strain gages on the gate strut mechanism.

The strain gages and accelerometers that were used to monitor activity were connected to a Campbell Scientific CR1000 Data Logger that was installed in the dam galley. The CR1000 with a AM16/32B Multiplexer was used to extend the number of channels that the logger is capable of monitoring. Each strain gage required one data channel. Each tri-axial accelerometer required three data channels. The data logger was housed in a 16 in. × 18 in. enclosure.

Figure 56. Installation of accelerometer.

Figure 57. Installation of strain gages.

Figure 58. Accelerometer and strain gages installed on gate struts.



Gate 1 (Bay 1), adjacent to the navigation lock wall, and Gate 4 (Bay 4), toward the middle of the navigation pass, were instrumented as part of this MCNP monitoring study. These gates (bays) were chosen to cover the range of boundary effects and hydrodynamic forcing functions experienced by the system of gates under all operating and navigation conditions. For purposes of this investigation, data were logged for the period 15 September 2013 through 25 February 2014. Data-acquisition strain gages and accelerometers, and the logging device, remain at MPLD for use by SWL personnel in obtaining additional force data on the bottom-hinged, torque-tube crest gates at future dates.

For the period of this gate load measurement investigation, the gates were (a) lowered on 29 September 2013, (b) raised on 1 October 2013, (c) lowered on 10 October 2013, (d) raised on 18 October 2013, and (e) lowered on 7 November 2013. Displays of the time histories of the strains (microstrain, με) experienced by the gate strut mechanisms are shown in Figures 59 and 60 for Gate 1 (Bay 1) and Gate 4 (Bay 4), respectively, for gate lowering on 29 September 2013. Displays of the time histories of the strain, με (10^{-6} ft/ft), experienced by the gate strut mechanisms are shown in Figures 61 and 62 for Gate 1 (Bay 1) and Gate 4 (Bay 4), respectively, for gate raising on 1 October 2013. Here can be seen that the strains were exceedingly low for all conditions during lowering and raising of these gates (on the order of ± 50 με). No adverse situations occurred during any of these MCNP investigations. Strains in excess of 1000 με would be required before serious concerns are raised.

A 1:15 scale structural model study had previously been conducted at USACE Waterways Experiment Station (de Bejar 1995) to evaluate the safety of the torque-tube gate in service against fatigue failure from flow-induced vibrations over time. That study indicated no significant flow-induced vibration problems in the model since the anticipated flow conditions over the life of the structure produced no outstanding oscillatory energy. No evidence was detected to indicate flow-induced vibrations of intensity sufficient to produce fatigue in components of the prototype. However, de Bejar (1995) concluded that absence of serious flow-induced vibrations in the physical model did not categorically ensure safety against fatigue in the prototype.

This prototype monitoring study by the USACE MCNP program confirmed the findings from the previous physical model study by de Bejar (1995) that serious flow-induced vibrations in the MPLD hinged, torque-tube crest gates do not occur during either raising or lowering the gates.

Figure 59. Time history of strain experienced by Gate 1 (Bay 1), gate lowering on 29 September 2013.

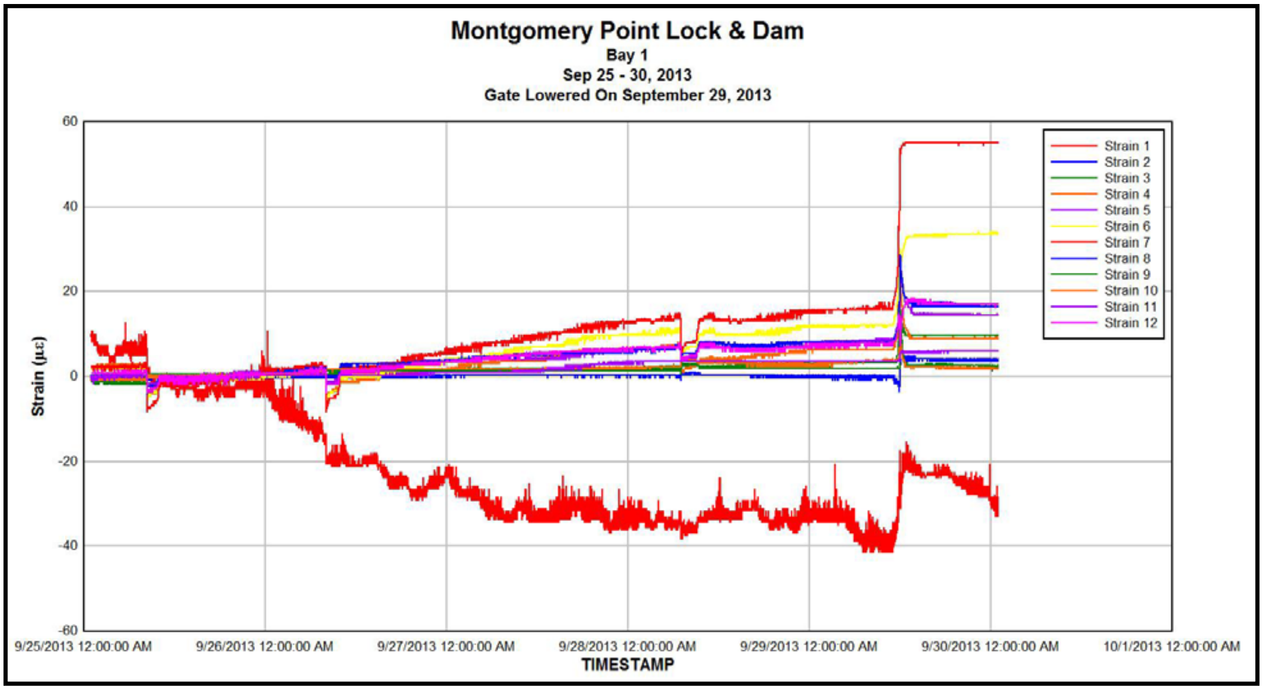


Figure 60. Time history of strain experienced by Gate 4 (Bay 4), gate lowering on 29 September 2013.

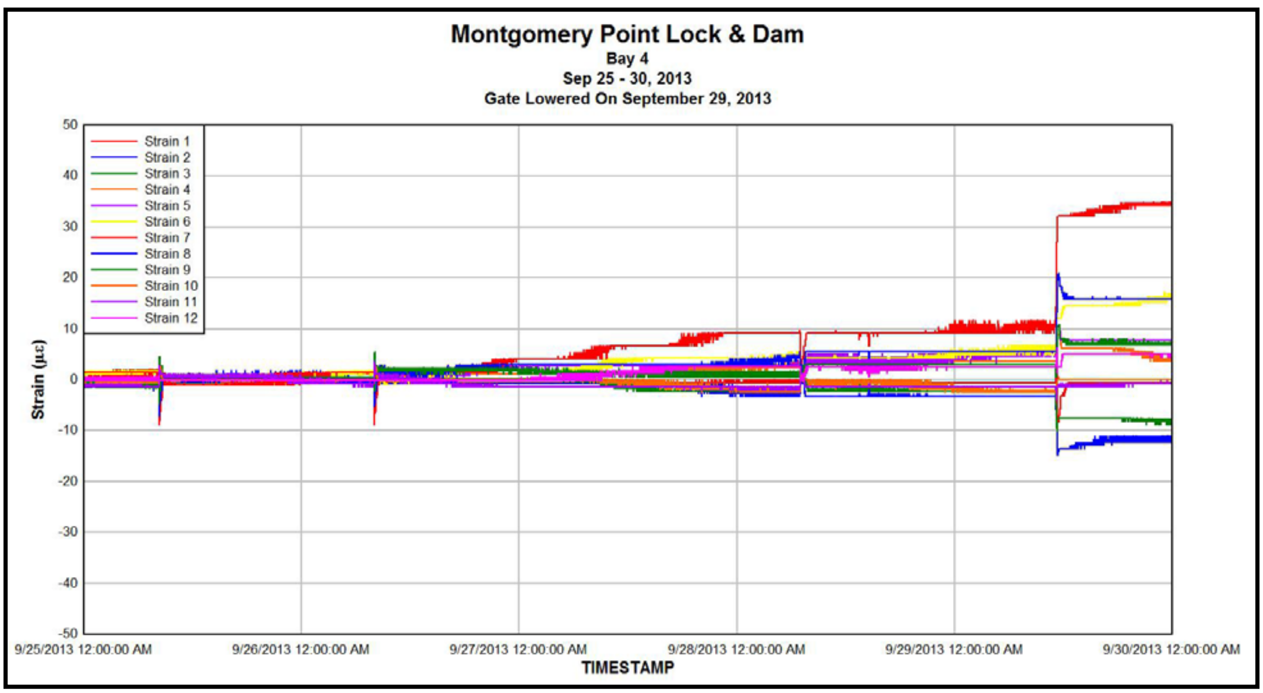


Figure 61. Time history of strain experienced by Gate 1 (Bay 1), gate raising on 1 October 2013.

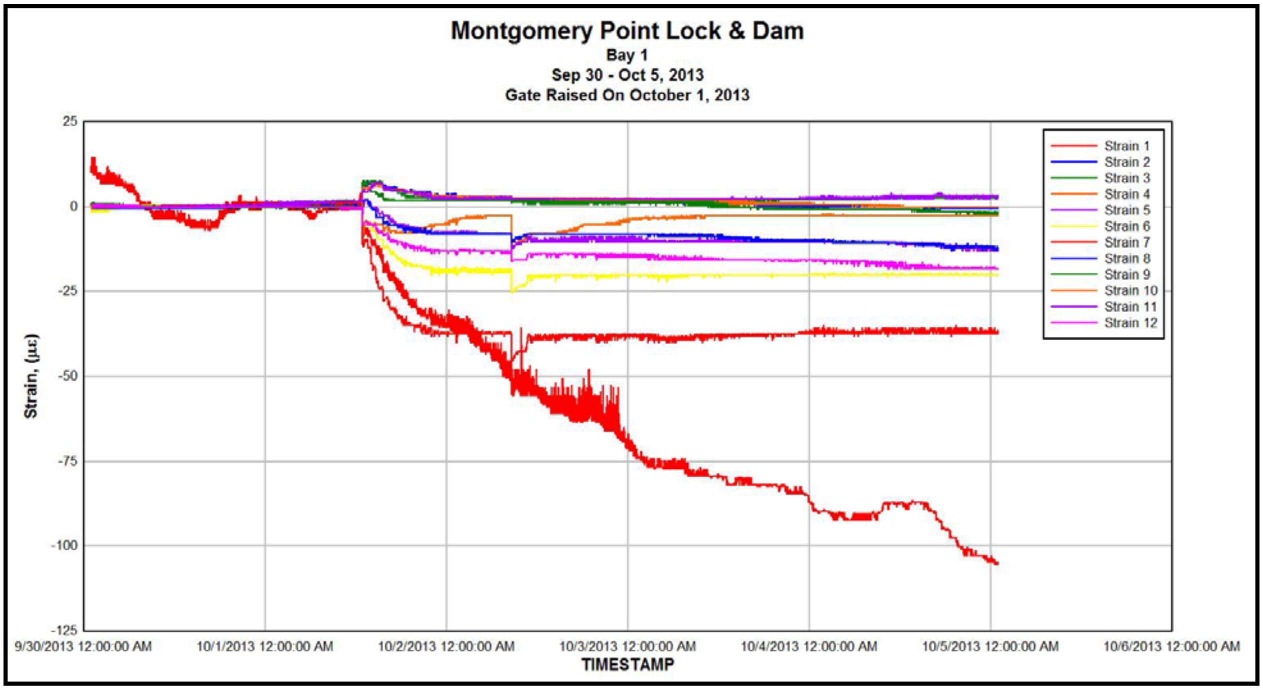
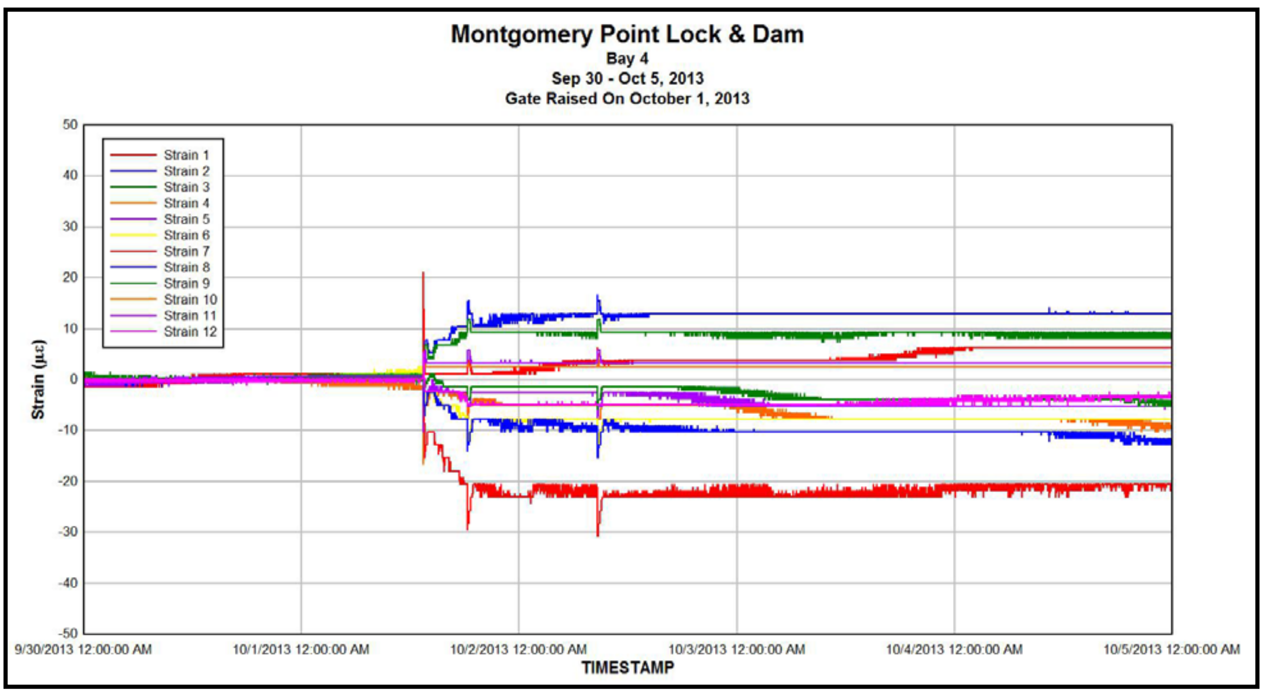


Figure 62. Time history of strain experienced by Gate 4 (Bay 4), gate raising on 1 October 2013.



5 Summary and Conclusions

Montgomery Point Lock and Dam (MPLD) is located on the lower White River in Arkansas, approximately 0.6 mile upstream from its confluence with the Mississippi River at River Mile 599 Above Head of Passes (RM 599 AHP). The MPLD project is a unique design located immediately downstream of a sharp curve in the White River. Characteristics of the project significant to this MCNP study include (a) a single-chamber lock on the right descending bank with usable dimensions of 110 ft wide by 600 ft long, lock floor elevation 77.5, (b) floating upstream guide wall and downstream guide wall, each approximately 524 ft long, (c) unique 300 ft wide, bottom-hinged, torque-tube crest gate navigable pass (crest elevation 102 ft NGVD29, with ten 30 ft wide gates) located between the lock and a concrete abutment pier, and (d) a 200 ft wide, fixed-crest concrete overflow spillway located between the concrete abutment pier and a spur dike attached to the left descending bank, crest elevation 115.0 ft NGVD29.

It was determined by the MPLD Product Delivery Team for this MCNP study that only five of the original seven elements proposed by SWL for investigation would actually be evaluated. These five elements are (1) scour hole downstream of overflow spillway and navigation pass, (2) sedimentation and deposition upstream of navigation pass, (3) lock and navigation pass upstream approach velocity conditions, (4) spillway gate leakage, and (5) forces on crest gates.

Three surveys were conducted by ERDC in May 2008, September 2008, and June 2009. The intent was to collect these data during high- and low-water periods. Dates of actual surveys were close but not precisely at high and low water elevations. Subsequently, a fourth survey was conducted by SWL in June 2010.

All field data acquired during the three field data surveys by ERDC were transmitted to SWL for District decisions regarding any navigational operational modifications or any operation and maintenance issues pertaining to scour below and sedimentation above the overflow spillway and navigation pass. These field data of 200 Khz, single–beam, echo-sounder bathymetry and acoustic doppler current profiler (ADCP) velocities from the three ERDC surveys, as well as the field data from the fourth survey by SWL were forwarded to the U.S. Army Engineer District, St. Louis (MVS), Applied River Engineering Center (AREC), for additional analyses and interpretation (Cox et al. 2011).

Scour hole downstream of overflow spillway and navigation pass

The grades of the stone protection downstream of the overflow spillway and the navigation pass were monitored to ensure grade and section were maintained. Field bathymetric survey data were collected with a 200 Khz, single-beam, echo-sounder hydrographic survey instrument during May 2008, September 2008, June 2009, and June 2009. This survey method proved to be exceedingly cost effective with high precision. Dates of the actual surveys were close but not precisely at high- and low-water elevations.

The bathymetry data collected in May 2008 concentrated on a scour hole just downstream of the navigable pass (Figure 26) that was of great concern due to potential undermining of the structures. A subsequent survey in June 2009 (Figure 27) showed that the scour hole had significantly deepened and widened, being about 23 ft deeper by 115 ft wide by 260 ft long.

The scour hole developed at this specific location because river flow at high water over the fixed-bed navigation pass is analogous to high-velocity turbulent flow over a weir. The resulting high-velocity currents provide forces capable of scouring the movable bed material comprising the river bottom in this vicinity. Based on these survey data showing significant scour hole enlargement between May 2008 and June 2009 (up to 23 ft), it was recommended that SWL fill and stabilize the scour hole with stone sufficiently large enough to prevent scour hole enlargement with resulting potential endangerment of the navigation structures.

Sedimentation and deposition upstream of navigation pass

A difference map showing the change in bathymetric elevations between May 2008 and June 2009 at the upstream approach to the lock and navigation pass is shown in Figure 31. The differences in elevation were insufficient to impede barge traffic, being only approximately 4–6 ft in very small areas of that reach of the waterway. No maintenance channel dredging was required because these small sections of deposition would be easily obliterated by propeller wash.

Lock and navigation pass upstream approach velocity conditions

Discharges and velocities

ADCP current direction and velocity field data were obtained by ERDC during the same period that the echo-sounder bathymetric field surveys were performed. Potential problems for navigation of barge traffic can be seen from flow conditions associated with outdraft and current re-alignment. Much of the flow passes under the upstream guide wall, around the lock, and toward the left bank and abutment pier. These field velocity data obtained by ERDC were also analyzed by AREC, and those analyses are reproduced herein, by permission.

While there was not an exact comparison of ERDC physical model data to ERDC prototype field data, much correlation could be deduced. The physical model indicated flow patterns very similar to those observed with the prototype data. The ERDC ADCP field velocity data for both the May 2008 and June 2009 surveys were obtained at near-high-water (elevation approximately 160.0 ft and 155.0 ft, respectively) on the White river, as seen in Figure 23.

These surveys indicated that flow is concentrated toward the RDB upstream of the lock approach. Flow enters the upper lock approach, but since the lock miter gates are closed, the flow passes under and around the upstream guide wall (outdraft) and moves toward the left end of the navigable pass and overflow weir. During high water, flows passing under and around the upstream guide wall have been difficult to predict, and as a result, conditions have been difficult to navigate (five significant allisions have occurred since opening the lock on 24 August 2004). This general trend was also observed in the ERDC physical model. No precise comparison could be made in current magnitude between the prototype and the physical model due to slight differences in discharges and tailwater elevations.

Tow time-lapse videos and AIS

Time-lapse video equipment was installed at the project to observe navigation conditions for tows entering and leaving the lock and transiting the navigable pass. Such data would allow project personnel to observe how vessels had transited the lock or navigable pass, coupled with the flow conditions at the time of transit. Also, in the case of an accident, provided the vessel was in view, judgment as to what may have caused such an accident could be deduced. During the monitoring period (January–December 2011), most of the vessel traffic transited the navigable pass. Therefore, the functionality of the upper and lower lock approaches when compared to physical model results could not be fully ascertained. No untoward barge vessel incidences occurred during the time interval when the video cameras were in place at MPLD. Continued time-lapse video footage in the future could provide information needed to further evaluate the functionality of the upper and lower lock approaches.

An AIS was also installed to observe vessel traffic through the general vicinity of the lock. Information such as speed and heading available through the AIS database can be used to produce general tow track plots of vessels transiting the locks or navigable pass. Such data are essential for recreating navigation hazard incidences but were not required during this time period as no adverse impacts occurred.

Time-lapse video and AIS equipment should continue to be utilized when there are moderate to high flows on the White River and the Mississippi River is falling. Notices to mariners should re-emphasize potential hazards under these conditions to avoid future allision with the navigation structures.

Spillway gate leakage

Spillway gate leakage could only be measured when the tailwater elevation recedes to 115 ft NGVD29 (low water) and the gates are in a raised position. Discharge would be inferred by taking ADCP velocity measurements across the water column and integrating over the cross-sectional area to obtain quantity of spillway gate leakage.

The pool elevation was at high water all three time periods when ERDC conducted field surveys: (1) May 2008, elev. = 150 ft NGVD29, (2) September 2008, elev. = 125 ft NGVD29, and (3) June 2009, elev. = 135 ft NGVD29 (Figure 23). The gates were not in a raised position during any of these ERDC field surveys. A necessary prerequisite for measuring spillway gate leakage and verifying the physical model estimates was that the gates must be in a raised position. Hence, it was not possible to accomplish this element that was originally scheduled to be monitored.

Forces on crest gates

The total load on the bottom-hinged, torque-tube crest gates could not be obtained directly. Expected normal loads are 200 kips tension to 500 kips compression with overloads up to 760 kips maximum compression. Loadings on the gates were deduced to be well within safety tolerance by placing strain gages and accelerometers on the gate struts located in the galley of the dam to monitor strain loadings during raising and lowering of the gates. These data acquisition equipment and the logging device remain at MPLD for use by SWL personnel in obtaining additional force data at future dates. The strains were exceedingly low for all conditions during lowering and raising of these gates (on the order of $\pm$ 50 $\mu\varepsilon$). Strains in excess of 1000 $\mu\varepsilon$ would be required before serious concerns are raised. No adverse situations occurred during any of these MCNP investigations.

This prototype monitoring study by the USACE MCNP program confirmed the findings from the previous physical model study by de Bejar (1995) that serious flow-induced vibrations in the MPLD hinged, torque-tube crest gates do not occur during either raising or lowering the gates.

References

Carter, Kenneth W. 2005. *Memorandum for Commander, Engineer Research and Development Center: Subject; Nomination for the Monitoring Completed Navigation Projects (MCNP) Program*. Little Rock, AR: Chief, Engineering and Construction Division, U.S. Army Corps of Engineers, Little Rock District.

Cox, A. N., J. L. Brown, R. D. Davinroy, I. H. Nguyen, J. J. Floyd, D. Fischer, and J. Mewes. 2011. *Montgomery Point Lock and Dam HSR model, White River miles 4.0 – 0.0; Hydraulic sediment response model investigation.* Technical Report M55. St. Louis, MO: U.S. Army Corps of Engineers, St. Louis District, Hydrologic and Hydraulics Branch, Applied River Engineering Center.

de Bejar, L. A. 1995. *Montgomery Point Lock and Dam study: Report 2; Montgomery Point torque-tube gate, A structural model study*. Technical Report HL-95-14. Vicksburg, MS: U.S. Army Corps of Engineers, Waterways Experiment Station.

Fletcher, B. P., and L. de Bejar. 1995. *Montgomery Point Lock and Dam study: Report 1; Hydraulic forces and characteristics acting on spillway gates.* Technical Report HL-95-14. Vicksburg, MS: U.S. Army Corps of Engineers, Waterways Experiment Station.

Headquarters, U.S. Army Corps of Engineers (HQUSACE). 1997. *Engineering and design: Monitoring completed navigation projects*. Engineer Regulation ER 1110-2-8151. Washington, DC: Headquarters, U.S. Army Corps of Engineers.

Himstedt, H. 2015. Personal communication of 6 June 2015 from Henry Himstedt, U.S. Army Engineer District, Little Rock, to Lyndell Hales, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Wilson, D. C. 2007a (unpublished document). Montgomery Point Lock and Dam: Hydraulic model study. Vicksburg, MS: U.S. Army Research and Development Center.

Wilson, D. C. 2007b (unpublished document). Montgomery Point Lock and Dam: Sediment model study. Vicksburg, MS: U.S. Army Research and Development Center.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED (From - To)
January 2016	Technical Report	2008 - 2012

4. TITLE AND SUBTITLE
Montgomery Point Lock and Dam, White River, Arkansas

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Allen Hammack, Michael Winkler, and Howard Park

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CHL TR-16-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
441 G. Street, NW
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Montgomery Point Lock and Dam employs a unique design and is located immediately downstream of a sharp curve in the White River, AR. Bathymetric survey data were collected during May 2008, September 2008, June 2009, and June 2010. A scour hole just downstream of the navigable pass deepened and widened between May 2008 and June 2009 to dimensions 23 ft deep by 115 ft wide by 260 ft long. It was recommended that the U.S. Army Engineer District, Little Rock, fill and stabilize the scour hole with stone large enough to prevent further enlargement with potential endangerment of the navigation structures. Approximately 4–6 ft of deposition occurred during this time period in very small areas of the upstream approaches to the lock. No maintenance channel dredging was required because these small sections could be easily obliterated by propeller wash. Current direction and velocity data indicate that much of the flow passes under and around the upstream floating guide wall due to significant outdraft and moves toward the navigable pass and overflow weir. This makes downstream barge alignment with the navigation pass difficult when there are moderate to high flows on the White River and the Mississippi River is falling. It was recommended that notices to mariners re-emphasize potential hazards under these conditions to avoid future allisions with the navigation structures. Loadings on the navigation crest gates were deduced to be well within safety tolerance by placing strain gages and accelerometers on the gate struts located in the galley of the dam to monitor strain loadings during raising and lowering of the gates. This study confirmed the findings of a previous physical model study that serious flow-induced vibrations do not occur during either raising or lowering the navigation crest gates.

15. SUBJECT TERMS

	Floating guide walls	Navigation pass
ADCP velocity data	Forces on crest gates	Overflow spillway
Concrete abutment pier	Hinged crest gates	Scour hole

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Howard Park
Unclassified	Unclassified	Unclassified	SAR	66	19b. TELEPHONE NUMBER (Include area code) 601-634-4011